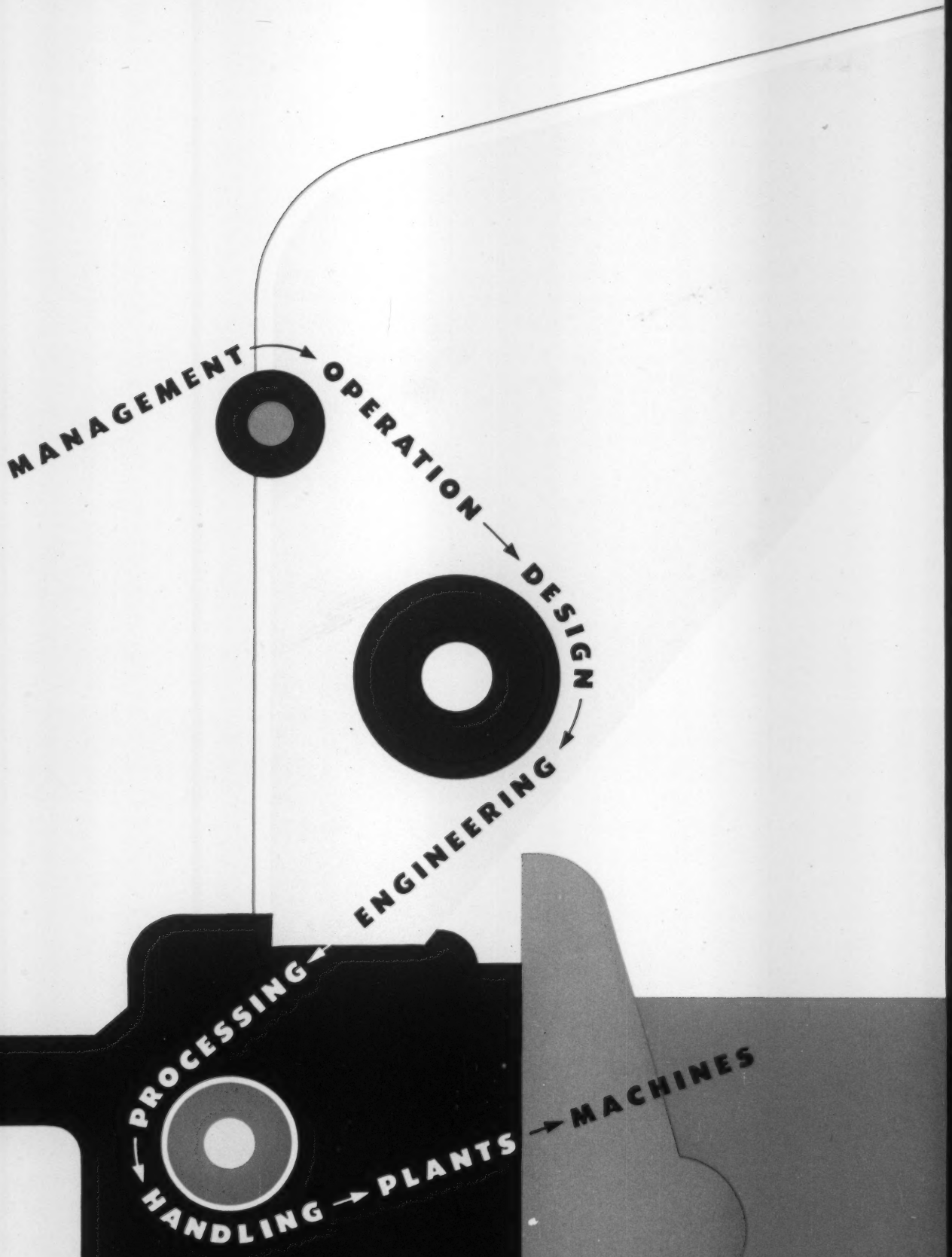
AUTOMATION

SEPTEMBER 1954



A PENTON PUBLICATION

WEAN "AUTOMATED" TRANS-CAR LINE SOLVES HEAVY PARTS HANDLING PROBLEM

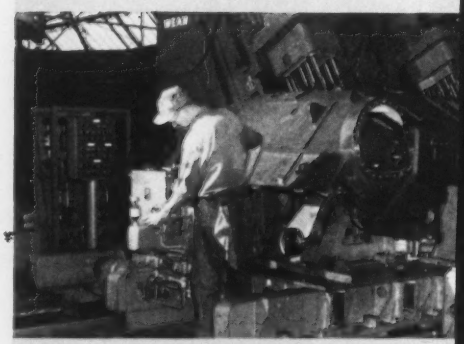
Unique system carries bulky sections through entire machining operation

The Massey-Harris Co. is used to handling and precision working large machine components. Thus, when they accepted the contract to produce combat vehicle hulls for the Army they immediately got in touch with Wean Equipment engineers.

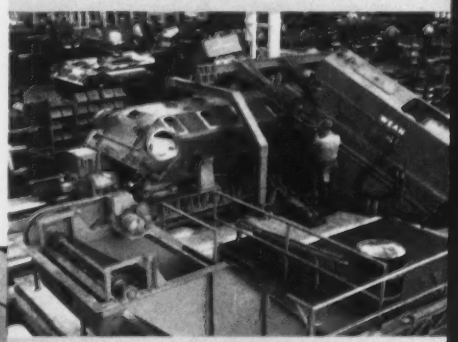
A team of Wean Equipment engineers working with a similar group from Massey-Harris soon vetoed the possibility of using standard machine tools on a cost basis. It was decided a complete line, especially built to do the job, was the only practical answer.

In eight months' time, Wean Equipment developed and built the now famous trans-car line. The line is composed of three stations: milling, drilling, and boring. The unusual feature is the car that operates on a set of tracks, running between stations, and eliminates all handling of the bulky, heavy hull.

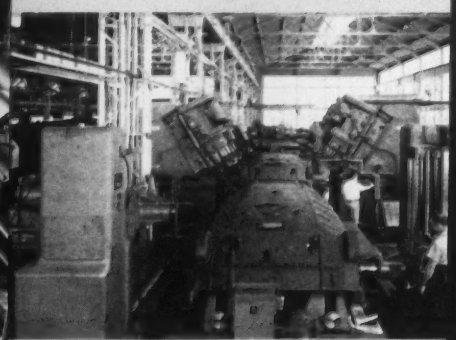
If special "automated" machinery is what you're looking for, call in a Wean Equipment man today. He represents probably the widest experience in specialized machinery to be found anywhere. Like Massey-Harris, you'll find Wean the surest, most inexpensive way to soundly engineered, result-getting machinery.



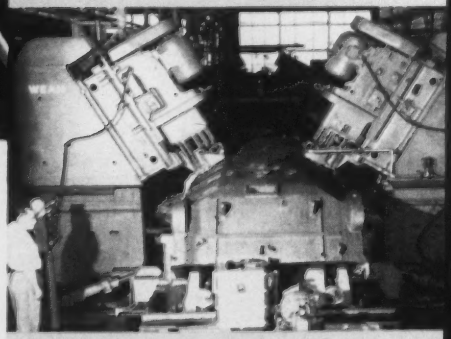
Unique trans-car that carries hull from station to station.



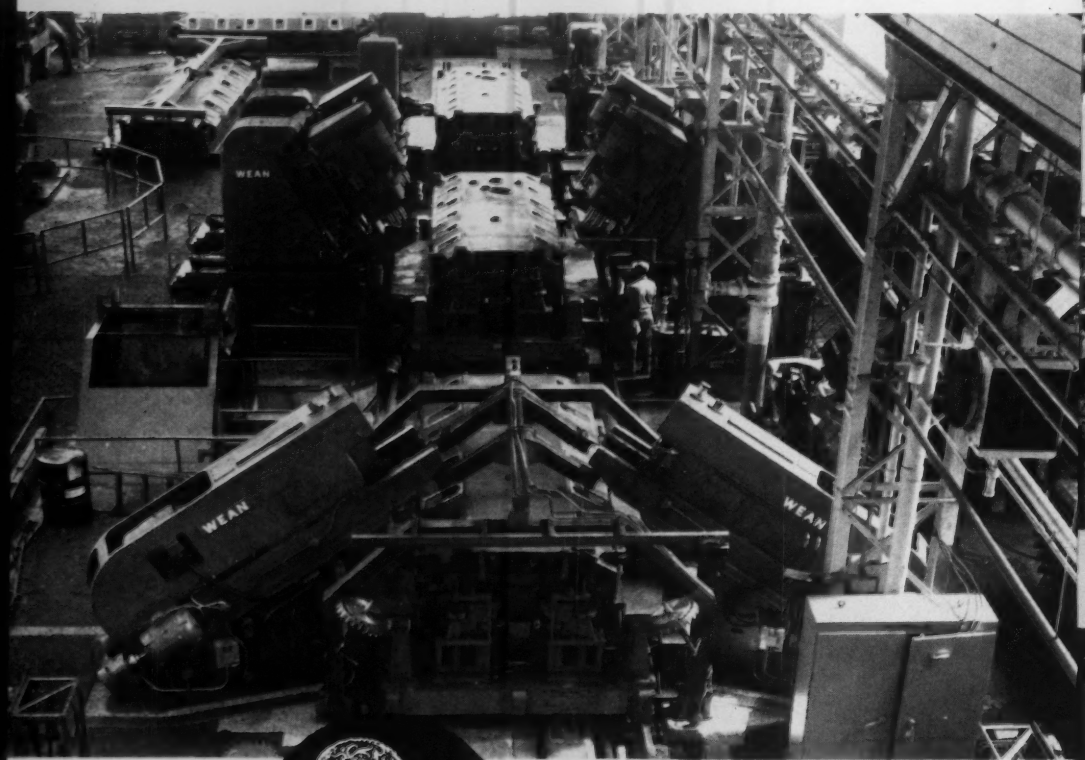
Milling operation. Dry cutting with carbide cutters. Air jets remove chips.



Drilling operation. Beneath the floor a coolant system with magnetic chip separator.



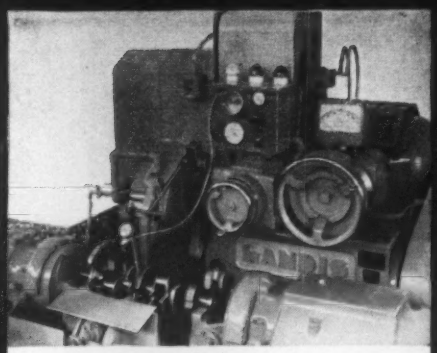
Boring operation. Drills, taps and reamers are of high speed steel. All operations are automatic.



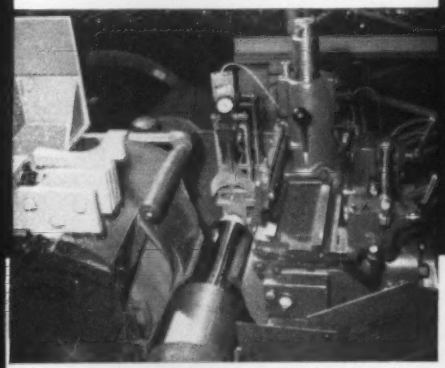
Over-all view of Wean Line that effected tremendous savings in producing giant hulls.

Wean

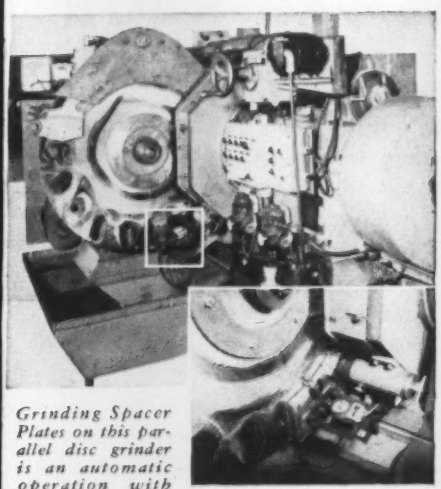
EQUIPMENT CORPORATION
CLEVELAND, OHIO



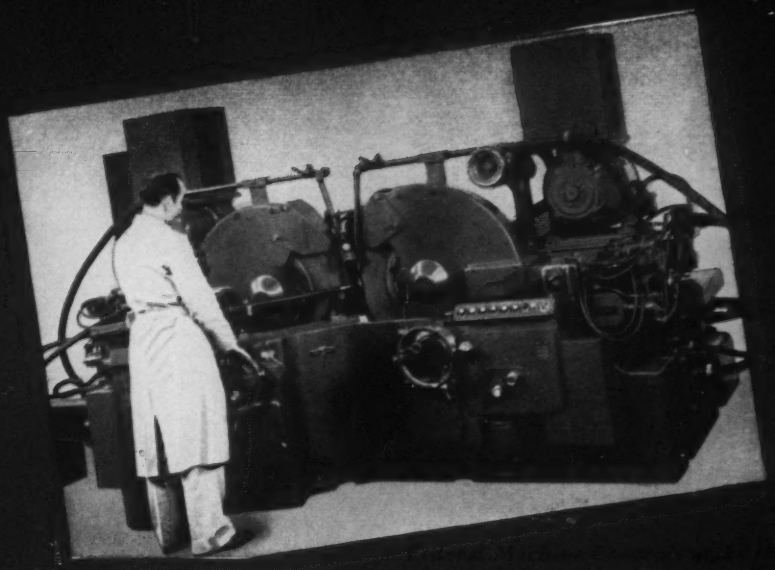
Grinding Main Journals on a Crankshaft is done quickly and without scrap with this Federal Air-Electric Grinding Gage. The operator loads the machine, snaps the caliper on the work and starts the machine cycle. When the work is down to size, the wheel automatically backs up. The large Air Dial and the three signal lights provide visual checks on the progress of the grinding. With this Machine Control Gage it is impossible to grind undersize scrap because the gage automatically backs the wheel up when work is to size.



This Federal unit, employing an Arnold continuous caliper type grinding gage, automatically controls the size of the journal surfaces of 1100 lb. freight car axles. The gage, ordinarily retracted to provide loading clearance, automatically springs onto the work and takes control of the grinding process at the start of the grinding cycle. Signal lights tell the operator when work is "over size", "near size", or "to size" and are connected electronically to the machine controls so the grinding cycle is automatically stopped when the required size is obtained. Tolerances are consistently maintained well within the plus 0.0005", minus 0.0000" specified.



Grinding Spacer Plates on this parallel disc grinder is an automatic operation with Federal Machine Control. Workpieces are loaded in the slotted carrier wheel and the gage controls the feed of the wheels to compensate for wheel wear. Corrections are made alternately to each wheel-head to maintain the centering of the carrier wheel. Automatic controls assure continuous production of good pieces, eliminating scrap.



FEDERAL *Automatic* MACHINE CONTROL GAGES

have established their efficiency

AUTOMATION is a new term applied to an idea that general machinery manufacturers have been doing ever since Eli Whitney invented his Cotton Gin. But, controlling Machine Tools automatically so that they produce work to required sizes is comparatively new.

Federal, however, has been designing and building Gages for this purpose for several years. We offer this tried and proven experience to all builders and users of machinery where Automatic Dimensional Control of Machine Tools is desired. We can handle all phases of the work; from work-handling through gaging, machine control and disposal.

Federal is ready to provide standardized package units for air, electrical, electronic or combination controls and **will cooperate with your engineers to adapt these to your machine requirements.** Call —

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FOR ANYTHING IN MODERN GAGES...

THIS BAKER gas-O-matic® UNLOADS 64,000 POUNDS OF RAW MATERIALS PER HOUR

• Cincinnati Chemical Works, Norwood Plant, unloads incoming raw materials from highway trailers or boxcars in the plant yard. Yard size limitations make speed essential since carriers often arrive at very short intervals. A former yard crew of ten men with hand trucks couldn't do the job fast enough, nor could three small battery-powered fork trucks installed several years ago.

The Baker 4,000 lb. Gas-O-Matic provides the speed and capacity to solve the problem. Materials in bags or drums are palletized inside trailers or boxcars, and carried in double-pallet loads to a warehouse elevator. Now two 16-ton full trailer loads arriving at the same time can be unloaded and material warehoused in 60 minutes. The electric trucks now work inside the building, and manpower saved was applied elsewhere.

The Gas-O-Matic also loads interplant trailers and does many other handling jobs, some of them involving a 280 ft., 10% ramp which the loaded truck ascends with ease. A second Gas-O-Matic at the nearby St. Bernard plant of Cincinnati Chemical performs similar tasks . . . In the six months that these trucks have been in service they have had no down time and no maintenance other than routine engine adjustment. They consume only about one gallon of gas for two hours work. Let a Baker representative show what Gas-O-Matic can do for you, or write The Baker-Raulang Company, 1202 West 80th St., Cleveland 2, Ohio and ask for Bulletin 1344.

Baker®
industrial trucks

SEPTEMBER, 1954
Vol. 1—No. 2

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATION

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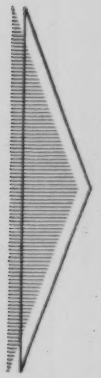

AUTOMATION OUTLOOK

NOT JUST FOR MASS PRODUCTION

". . . while it is probably true that the trend to automation is due to high production levels, it is fallacious to assume that automation, and particularly automated handling, is practical only for the higher production rates. Replacing an operator doing one operation a minute is often easier than replacing one doing sixty operations a minute, and the savings are just as great. It is possible for management to overlook opportunities for great savings and choose applications with many problems, simply because of preconceived ideas of when automation should be applied . . ."—*Charles E. Kraus, Kraus Design Inc.* *See page 20.*

THIS TOO IS AUTOMATION

". . . system control is still a most important factor and will be for years to come, but we already hear of future control systems that will theoretically lead us to the utopian automatic factory. It is hard to say whether the idea is being fostered by users, manufacturers or the public. There is no doubt that we will see a healthy trend in this direction in the next few years. From a practical angle, however, only a small percentage of our industries will be immediately affected, and in most of these the automation will be limited to special units or sections of the plant. . ."—*R. A. Bristol, treasurer, Foxboro Co.*

EYES ADD COMFORT, SAFETY

". . . industrial TV, with its closed circuit, can bring almost any operation—no matter how remote, hot, cold or dangerous—under the gaze of the human eye and, as techniques are refined, under the scrutiny of the automatic machines of the future. In the dreamed-of automatic factory, there always had to be one man to watch the instrumental panel. In the dream for tonight, that lonely fellow sees more than dials and gauges. TV eyes can roam the plant for him, watching every process, checking every reaction. Steel mills demonstrate what's been done so far. Here men pour molten steel in comfort, a half block away and upstairs, each move determined by a picture on his TV screen. TV eliminates close-up operation often involving accidents, unbearable heat, error and waste. . ."—*The York Report.*

FLEXIBILITY FOR SMALL LOTS

". . . a prime requirement for automation of small-quantity production, electronic assemblies or metalworking operations, is flexibility. Flexibility to change what is being made with a minimum of down-time on the equipment, a minimum of set-up skill required, a minimum investment in time and money in tools, jigs, fixtures and other ancillary items pertinent only to one particular product. . ."—*Walter Hausz, manager, Electronics Div. Laboratories, General Electric Co.*

OBJECTIVES SERVED

". . . what, then, are the trends to which the designer should be alert in planning the mass-production tools of tomorrow? . . . These objectives will be served by continued emphasis on automatic features, design which will simplify the maintenance problem in the large plant . . . there will be a growing emphasis on cutting the time involved in performing nonproductive elements of the work and reducing down-time. Automatic loading will come in for its share of attention . . . automatic gaging features will find increased use. . ."—*Frederick S. Blackall, Jr., president and treasurer, Taft-Peirce Mfg. Co.*

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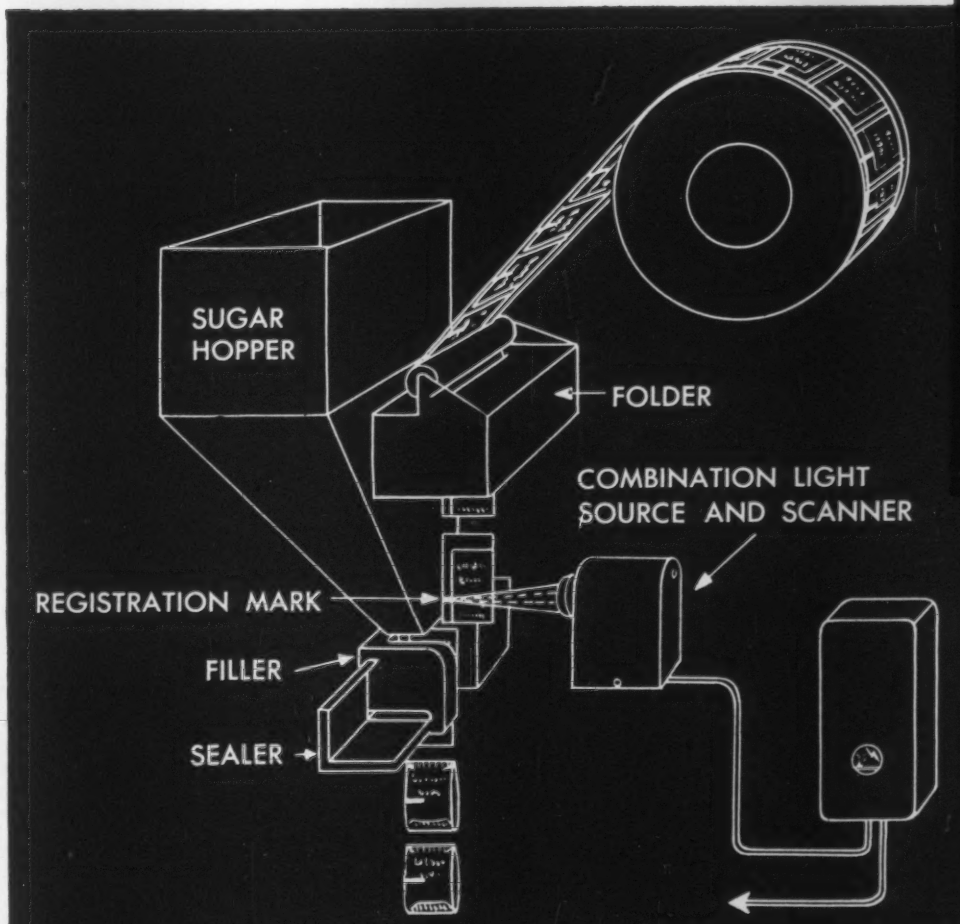
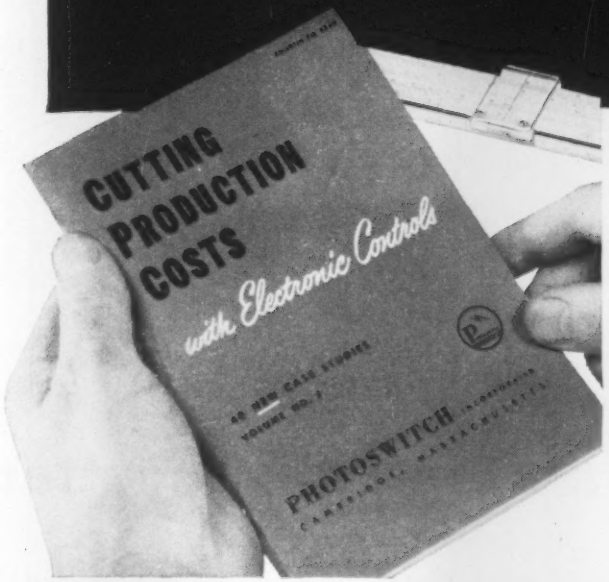
Automatic Control

Idea of the month...

from the Largest Specialist in Photoelectric Controls





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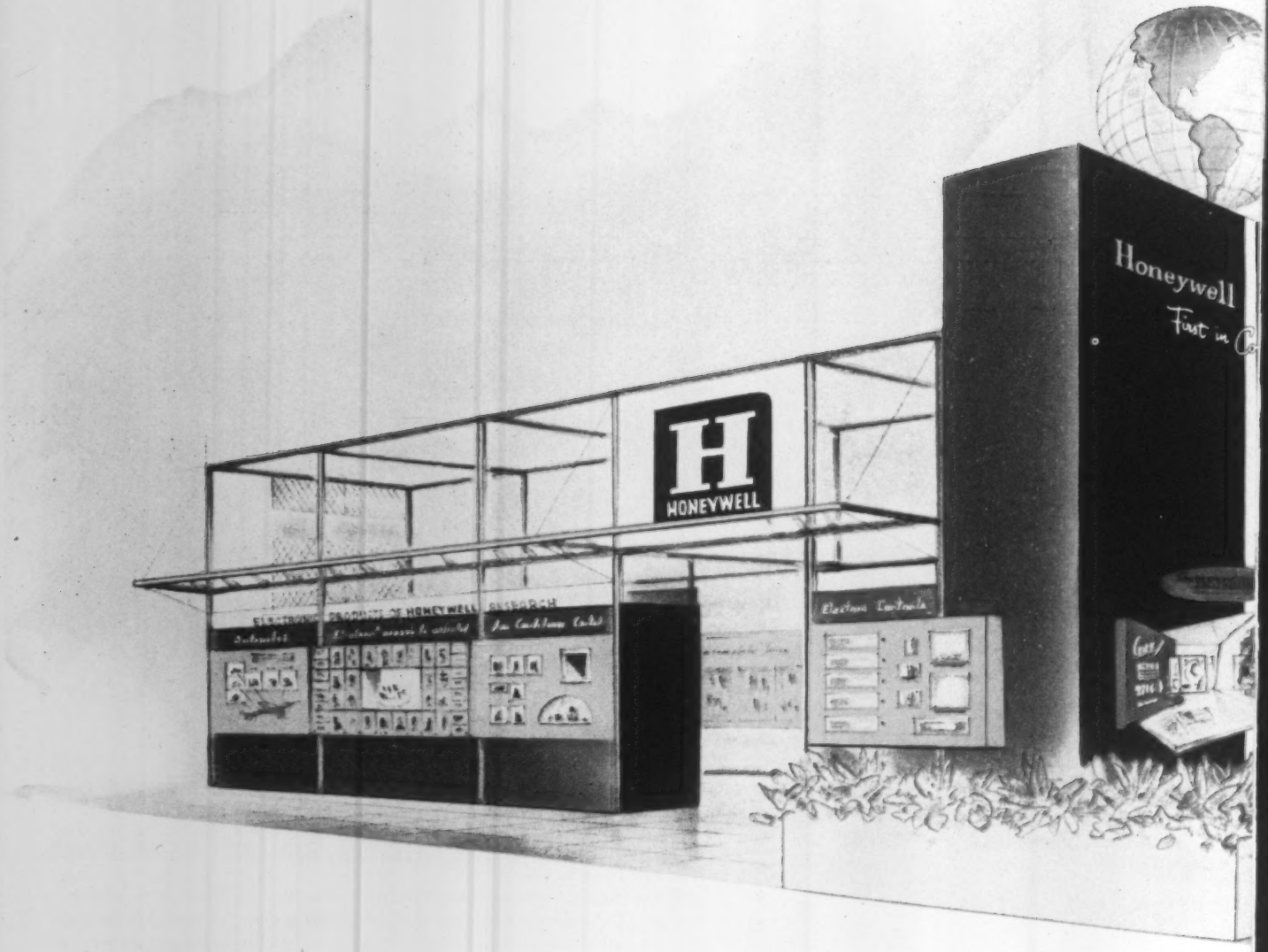

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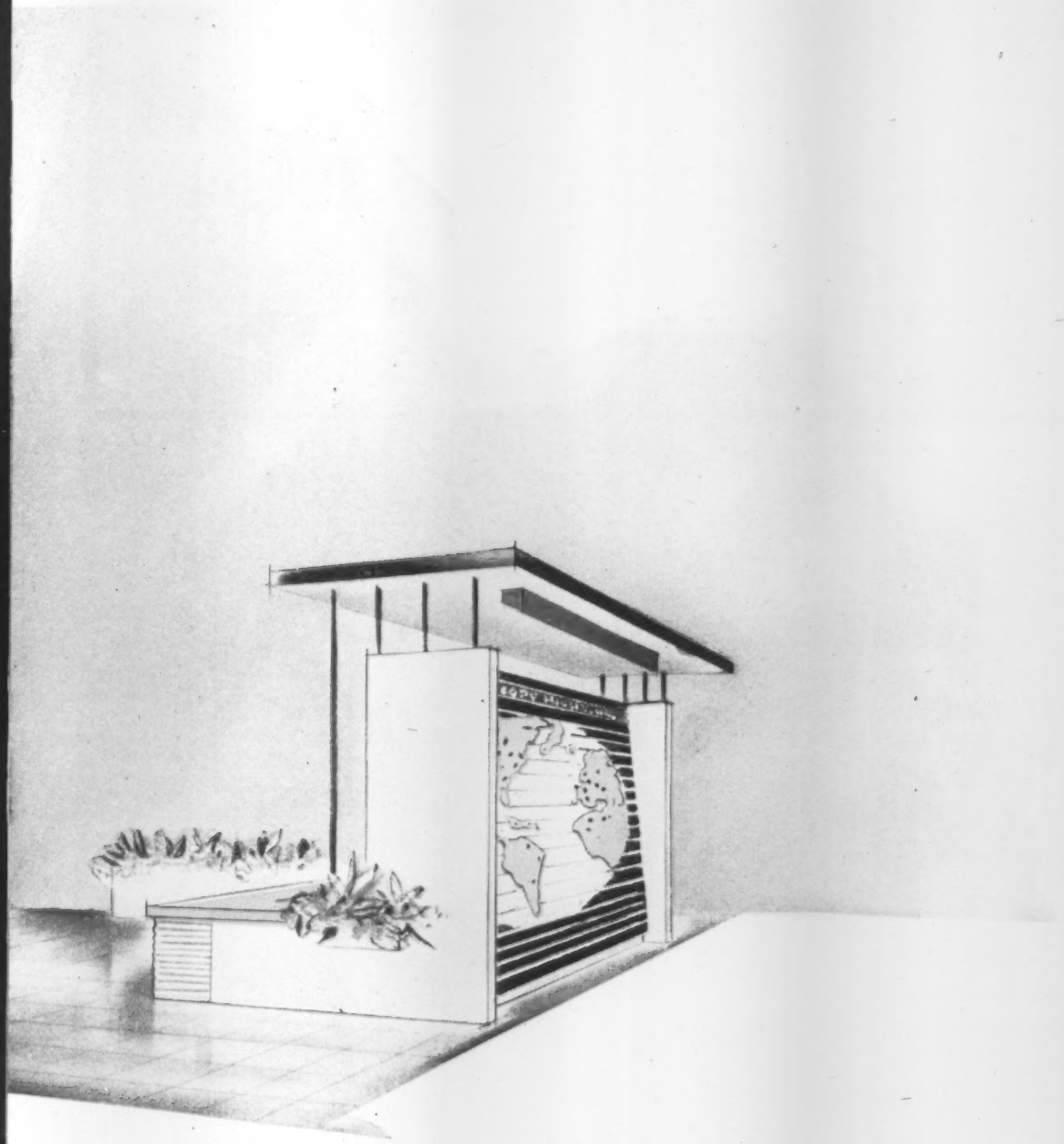

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Beveloid Gearing

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Calculating Dynamic Characteristics of Mechanisms

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Predicting Performance of High-Speed Mechanisms

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Analysis of Mechanisms with High-Speed Photography

E. A. EDWARDS, *Eastman Kodak Co.*

Panel Group Discussions

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Chairman A. S. HALL, *Prof., Mechanical Engineering, Purdue*

Mechanism Manufacturing Tolerances—How Good?

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Session 3—Cam Design Problems

Cam Design and Manufacture

P. MAKER, *Bryant Chucking Grinder Co.*

Vibration Analysis of Cams

C. N. NEKLUTIN, *Universal Match Co.*

Session 4—Control Mechanisms

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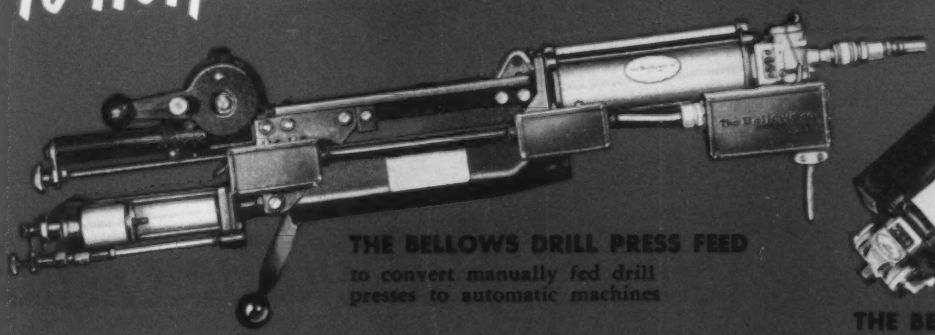

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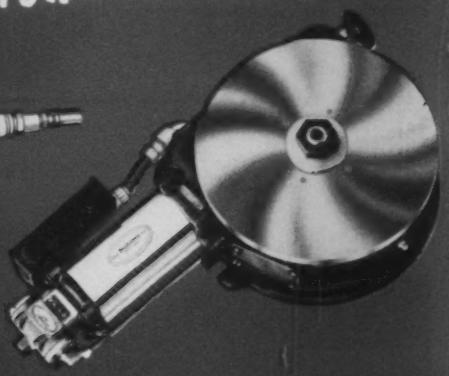
to convert manually fed drill presses to automatic machines



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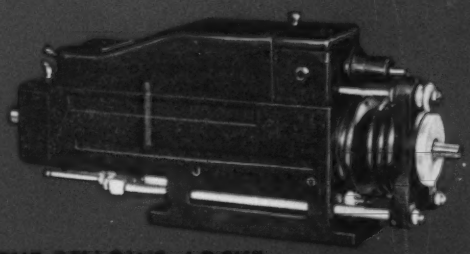
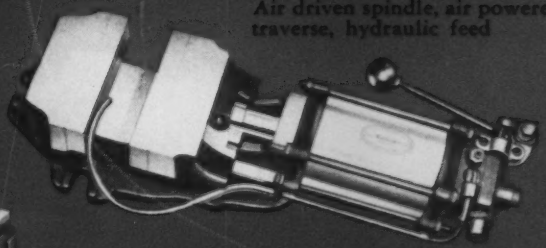


THE BELLOWS- LOCKE DRILL UNIT
Electrically driven spindle, air-powered traverse, hydraulic feed

THE BELLOWS HYDRAIR DRILL UNIT
Air driven spindle, air powered traverse, hydraulic feed



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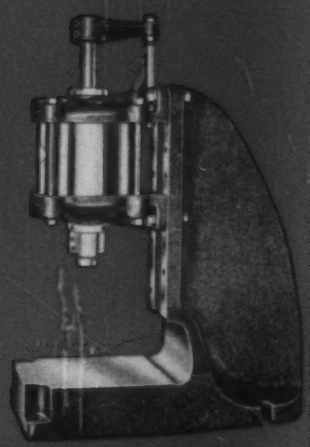
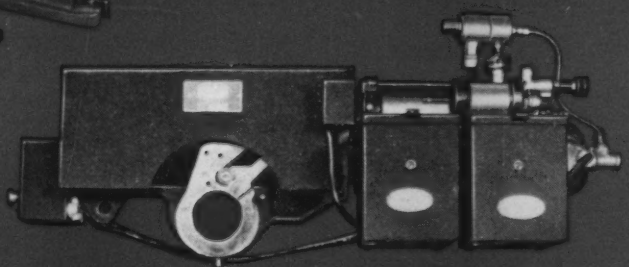
A ready made jig for handling small parts



THE BELLOWS TRANSFEED
a two position work feeder — operator loads and unloads while work is going on



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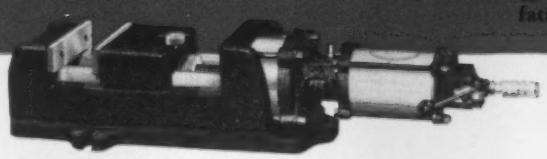

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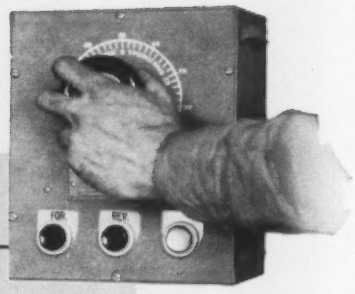

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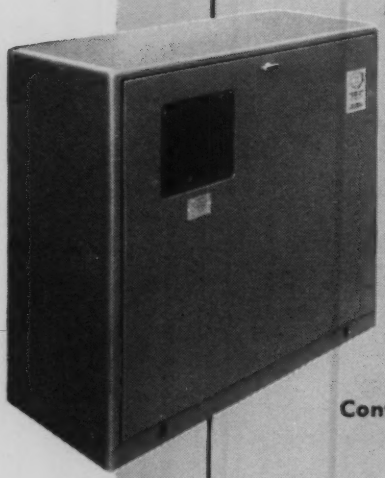

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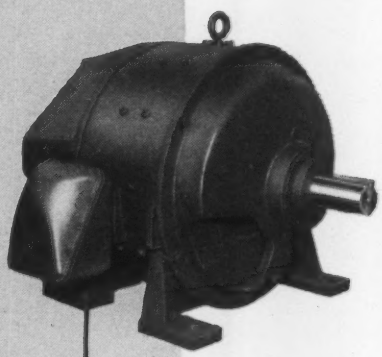

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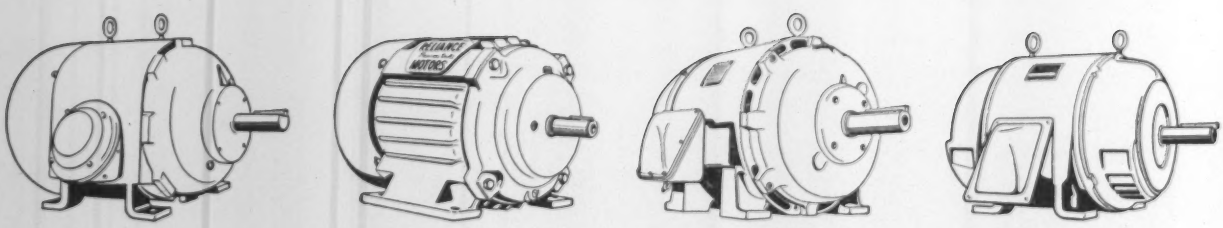

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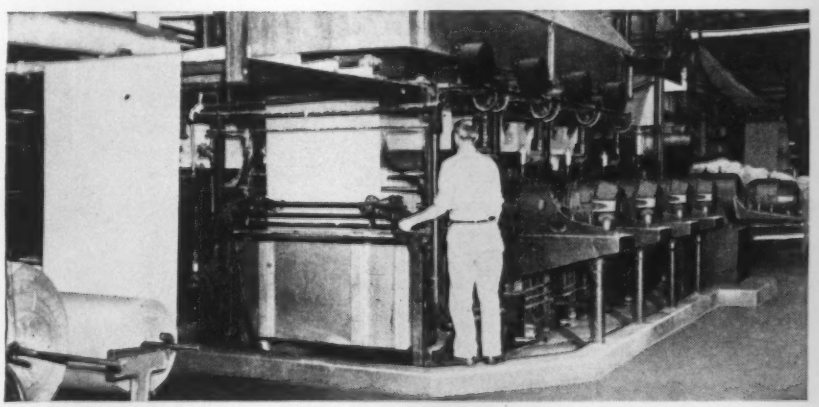

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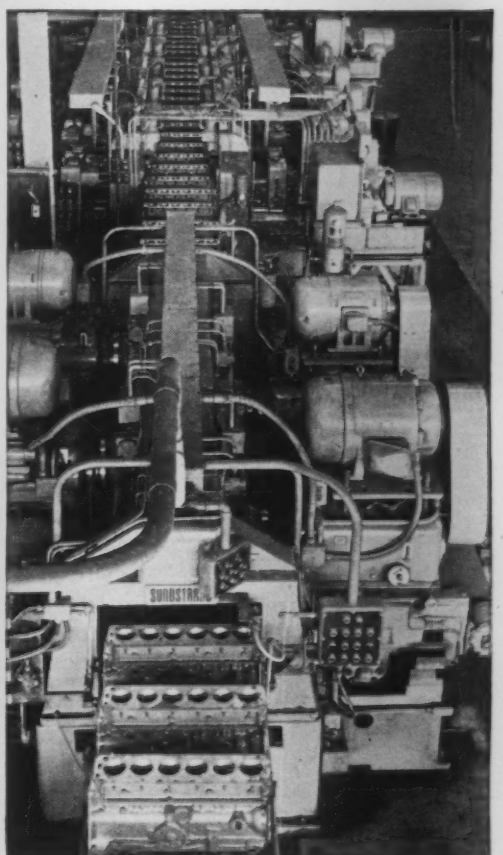

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Key to Millennium

A great deal has been said and written concerning the dire sociological and psychological effects and influences to be expected with the advance of automation. It is granted, of course, that there will be some general adjustments necessary and certainly management plans should include adequate consideration of means by which their development can be modified or channeled into helpful directions. To do this effectively, however, requires a clear picture of the true attitude of the working people involved.

Particularly pertinent in this regard is the statement of Eric Hoffer, longshoreman and author of *The True Believer,* in a recent article in *Harpers.*

"Contrary to the doctrine propounded by some in the heyday of the Industrial Revolution, at least here on the docks, no (worker) worries lest machines cut down earnings. We know we shall manage to get our full share no matter what happens. It is a dull workingman who does not see in the machine the only key to the true millennium. For only mechanization can mitigate—if not cure—'the disease of work', as de Tocqueville calls it, which has tortured humanity since the first day of its existence."

From this rational viewpoint shared by a majority, a sound modern management program can be created to keep pace with developments. The primary purpose of automation, broadly speaking, is not to displace working people. Rather, it is in the end the means by which the full talents of the operating personnel can be more effectively employed to lower the costs of production and distribution and increase the availability of capital and consumer goods. It is a continuation in the trend toward a higher standard of living, of substituting brains for brawn, adding to leisure time and providing an ever increasing market.

H. A. Bolz

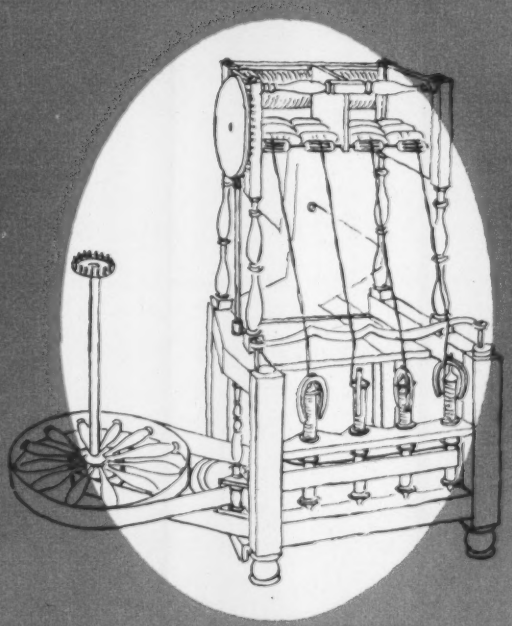
EDITOR

AUTOMATION

THE NEW AUTOMATION

ITS CHARACTER AND EFFECTS

New only in name, automation offers many economic advantages but demands increased management and engineering co-ordination along with much higher labor skills



Sir Richard Arkwright invented cotton spinning machinery in 1768. The spinners and weavers were up in arms. Yet three years after Arkwright's death the number of spinners and weavers had grown from 7900, at the time of the invention, to 320,000. Today this story is being repeated with automation

By ROGER W. BOLZ
Editor

AUTOMATION, the modern name for the marvelous composite of automatic operations and the automatic plant as developed and envisioned, has provoked much thinking and conjecture concerning some of its characteristics and influences. Basically it consists of relating, co-ordinating and integrating machines, mechanisms, controls, and processes to the extent that partial or complete evolution from the primary state to useful end product or service is accomplished automatically, without use of human hands.

Automation in Transition

Seemingly new and revolutionary, it is not. Bursting into print because of broadening application in new and important fields, automation has seen a long steady development over the years. To a strong degree its use has been influenced by the ease with which processing and manufacturing could be accomplished by hand operations within acceptable quantity and cost levels, wherever acceptable cost and necessary speed were impractical of attainment mechanization developed. Witness the wood products field where for many decades completely automatic processing, handling, feeding, etc., of tremendous quantities of such items as handles has made possible the availability of these basic components at extremely low cost.

Today, these same principles are being applied to a much greater extent, in more complex operations and much more extensive plants with equally important results. In a dynamically expanding country with a tremendously increased population, no other development holds so much opportunity for an ever higher standard of living. Adherence to older methods would result in an ultimately untenable position. High cost would narrow markets, restrict sales, and create increasing social segregation; even if cost were of no consideration, labor would be insufficient; brawn would continue to supercede brain power; the trend of living standards would be downward.

"We introduced automatic controls in our company because we had no choice. It would be impossible for people to run the plants we are building today — so many variables have to be controlled, it would be impossible to operate without automatically controlled machinery."

F. A. Landee, Dow Chemical Co.

"Automation reduces labor tremendously. Our experience has shown that we can count on a reduction of 25 to 30 per cent in what we call 'direct' labor. But we don't get that net reduction, because we have to add other labor."

R. H. Sullivan, Ford Motor Co.

"Hopes—or fears—that workers will be replaced universally in the automatic factory of tomorrow is unadulterated rubbish. Machines are steadily eliminating arduous and monotonous labor but need for higher skills actually will be increased by automation as far ahead as man can see."

L. T. Rader, General Electric Co.

"It will require tremendous effort to bring automatic assembly to major units—to design into steel the flexibility of the human arm and fingers, directed by the human brain. But that it eventually will be done is not doubted. All these developments do not mean that the pushbutton plant is just around the corner or even on the horizon. They do mean that men are being progressively shifted into jobs that demand less muscle and more brain. The laborer is going to be less and less in demand, while the market for skilled labor continues to grow apace."

Automobile Manufacturers Association

Cost and Quality Factors

Concerning labor, one example is illuminating in this regard. Electric light bulbs today are blown in one plant on several automatic machines at a rate of 90,000 per hour. Some 230 employees man the plant. With 1927 methods and machines, some 75,000 men would be required to produce this quantity per hour and with 1934 techniques some 4000 — an impossible situation. While employee pay has risen considerably and quality immeasurably, there has been an 80 per cent reduction in lamp cost since 1934. Much time and effort now can be spent advantageously in improved engineering of both product and plant. Labor has been largely upgraded.

In areas such as those where mixtures of granular and fluid materials are processed into fused and molded solids, the exact character and quality of the end product depend greatly upon the control of the ingredients. Manual control of either batch or continuous mixing and blending as generally practiced resulted in a fairly high rate of loss and wide variation. As users improve and refine their applications, these variable-quality and costly products of necessity are forced to undergo improvement.

Quality can be improved and maintained only by automatic control of the ingredient mix. Cost is largely reduced by eliminating scrap and rerun and attaining faster output. In many cases, scrap and quality control alone account for significant savings. In one instance, by replacing hand inspection test with an accurate automatic test, not subject to operator variations, apparent scrap was reduced almost 50 per cent. In another instance, automatic metering and weigh feeding of ingredients eliminated millions of pounds of rerun. Cost savings are worthy of real concern but in many of these cases, actual losses fail to appear as such or are accepted as a necessary evil associated with the particular product.

An important byproduct of automation is the fact that it generally makes possible and often

creates higher quality end products. As in the automotive industry where manual assembly of critical bearings and torqued fastenings have always resulted in variable performance, automatic machine tightening of bolts is self-inspected. When the machine fails to develop the proper torque or detects a faulty bolt, it shuts down.

In the automatic feeding, chuting and orienting of mechanical parts to be assembled, parts must be perfect. Poor parts with flash or torn edges fail to feed properly. Unless high-quality precise pieces are used, considerable trouble may result with high downtime due to scrap problems.

This improved quality creates a more acceptable product with greatly improved performance. In addition, service guarantees can be made with assurance of customer satisfaction without excessive warranty service costs.

Labor and Automatic Machines

When mechanization and automation develops in an industry, what happens to labor? Is it displaced? Are the work positions available wiped out? Is the ultimate the workerless plant as so often predicted?

The answer, of course, is no. The complete and ultimate result is the upgrading of personnel. Brawn is replaced with brains. Tremendously increased skill, planning and supervision are required. Wherever automation has developed, men are at work — thinking, directing, planning, co-ordinating. It is fantastic to assume that automated systems will create the necessary end products, services and planning required. The actual case is that more men are required — but in different positions.

Labor saving devices actually create jobs. History proves this. Ford, today employs more people than prior to automation. In another plant employing over two times as many operators as maintenance workers, the switch to automation resulted in about equal numbers of operators and maintenance men. Automatic machines are not foolproof. They require many more skilled technicians for control and maintenance; much more advance planning and research preceding their operation; and many more sales and service industry personnel in the distribution end of the vastly increased end product market.

While there must be expected some difficulties and reorientation in a shift to automation, it is not unusual. There are always such changes with shifting and settling taking place in a continually changing and dynamic economy. Each new upheaval creates new enterprises, and automation today is expanding into a tremendous new industrial front.

Few men resent machines or mechanization. Most see in machines and automation the key to respite from dull drudgery and hard labor. There is little love for labor as such. Under automation circumstances, rather than seeking to develop labor incentive, the automatic equipment itself offers keen incentive to insure that it works efficiently. Matching wits with machines in surmounting problems seldom necessitates incentives; few technicians can resist the challenge.

Engineering and Management

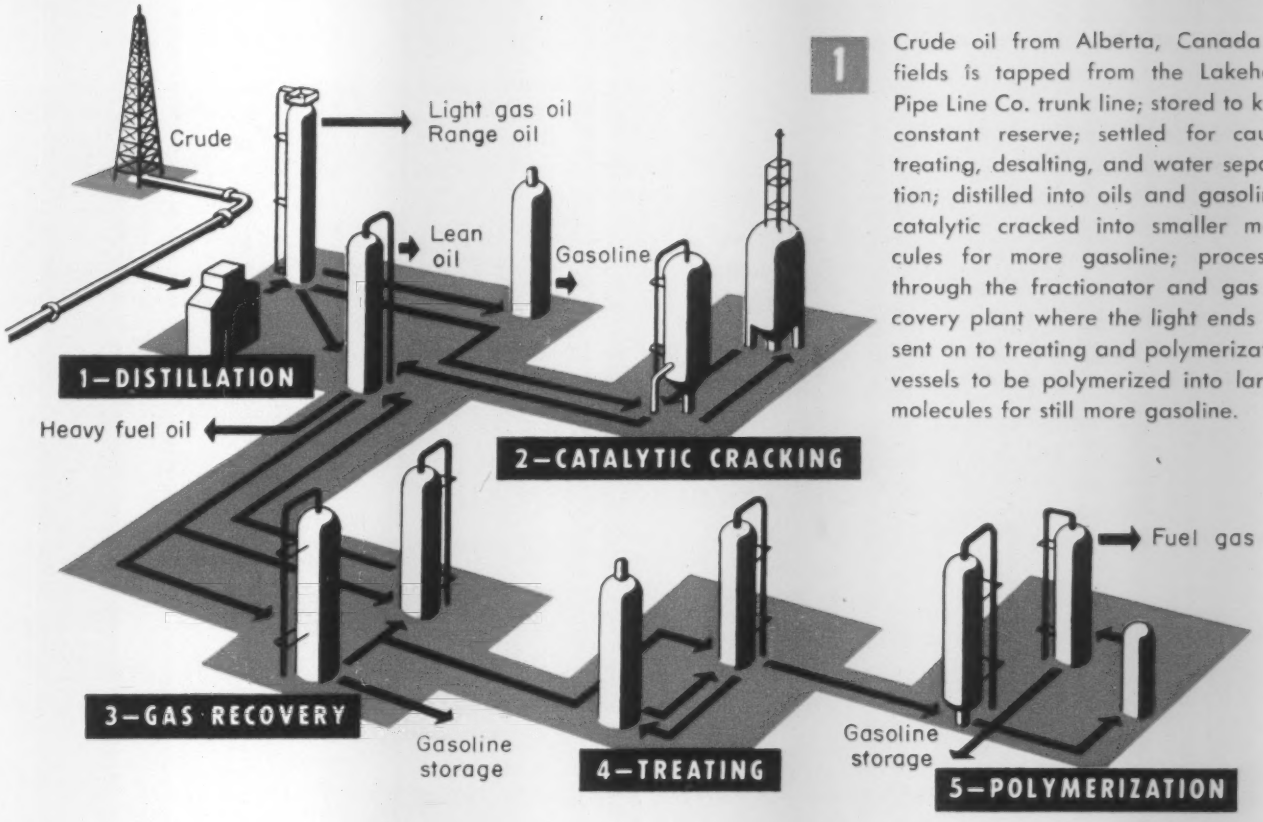
Automation also creates a greatly increased demand for engineers. Not only does the product or service to be automatically processed require better and more competent preliminary design, but so also does the equipment. Improved design for production is a must for economic reasons and for suitability to automatic processing. Greatly increased engineering time is inescapable in the engineering of automatic systems. Today, the engineering time and cost is paramount, the actual equipment construction cost pales into insignificance in comparison. The achievement of more widespread automation places a high priority on the supply of competently trained engineers and engineering technicians. Future rate of advance will be closely associated with their availability and the development of techniques and know-how. Necessarily, advance will be gradual rather than overnight.

Along with increased engineering staff and engineering activity, real achievement in automation requires a much closer co-ordination of top management and engineering. Successful application of automation principles necessitates full appreciation of all factors involved. It must be sparked by management and fully controlled since the effective climate for automatic operations includes many areas of the enterprise outside the sphere of engineering. Thorough research by management can often reveal the presence or adaptability of factors necessary for realization of automation.

The Future

Once the full perspective and potential of automation is apparent, its application in proper degree can result in real advance. Vastly improved working conditions and far greater development of potential interests and skills can be attained. The necessary engineering skill and knowledge and the necessary elements for automation are available. The question today is not will there be automation but how much and how soon, ahead of the push or behind?

In reviewing these economic and personnel aspects in the light of increasing automation, the future looks bright indeed. Never has such opportunity for advance been seen in a glimpse into the tomorrows. With full co-operation of engineering and management, with enterprise and imagination, with a keen awareness that the final justification of industry is in devotion to service and improved living standards, a new day will dawn unparalleled in history.



1 Crude oil from Alberta, Canada oil fields is tapped from the Lakehead Pipe Line Co. trunk line; stored to keep constant reserve; settled for caustic treating, desalting, and water separation; distilled into oils and gasolines; catalytic cracked into smaller molecules for more gasoline; processed through the fractionator and gas recovery plant where the light ends are sent on to treating and polymerization vessels to be polymerized into larger molecules for still more gasoline.

AUTOMATION TODAY

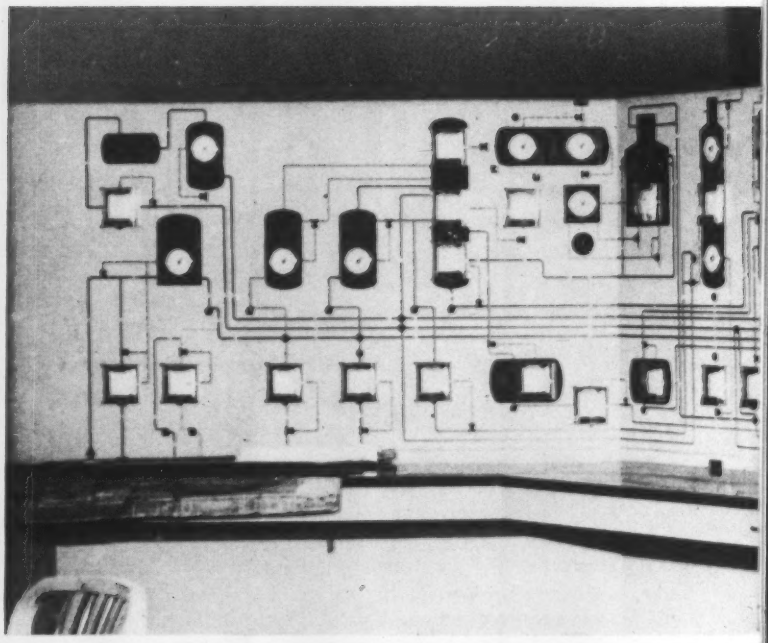
AUTOMATIC

OIL REFINING

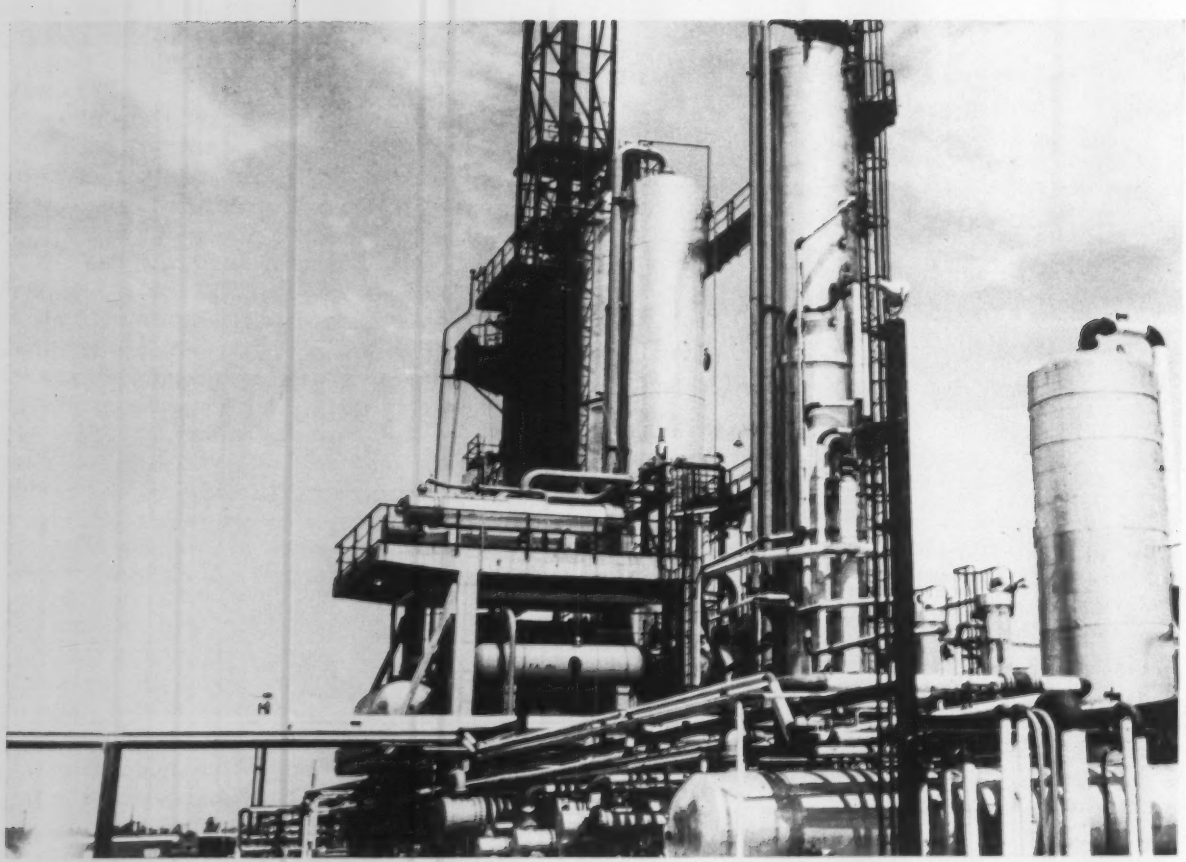
REALLY NEW in concept and design is the Wrenshall refinery which features continuous flow under fully automatic control. Using basically the same instrument components that have been in use for several years, full automation was achieved by designing the entire system around the required instruments. No radically new equipment was needed, only a thorough knowledge of the field and an unconventional approach.

Concerning the International Refineries Inc. installation in Carlton County near Wrenshall, Minn., Harold Hawkins, the instrument engineer, responsible for all process control instrumentation in the refinery has stated, "To the consumer, it means better fuels and gasolines at reasonable prices; to the country, conservation of our national resources through better refining processes; to the refinery employee, more security and better pay as productivity increases through automation."

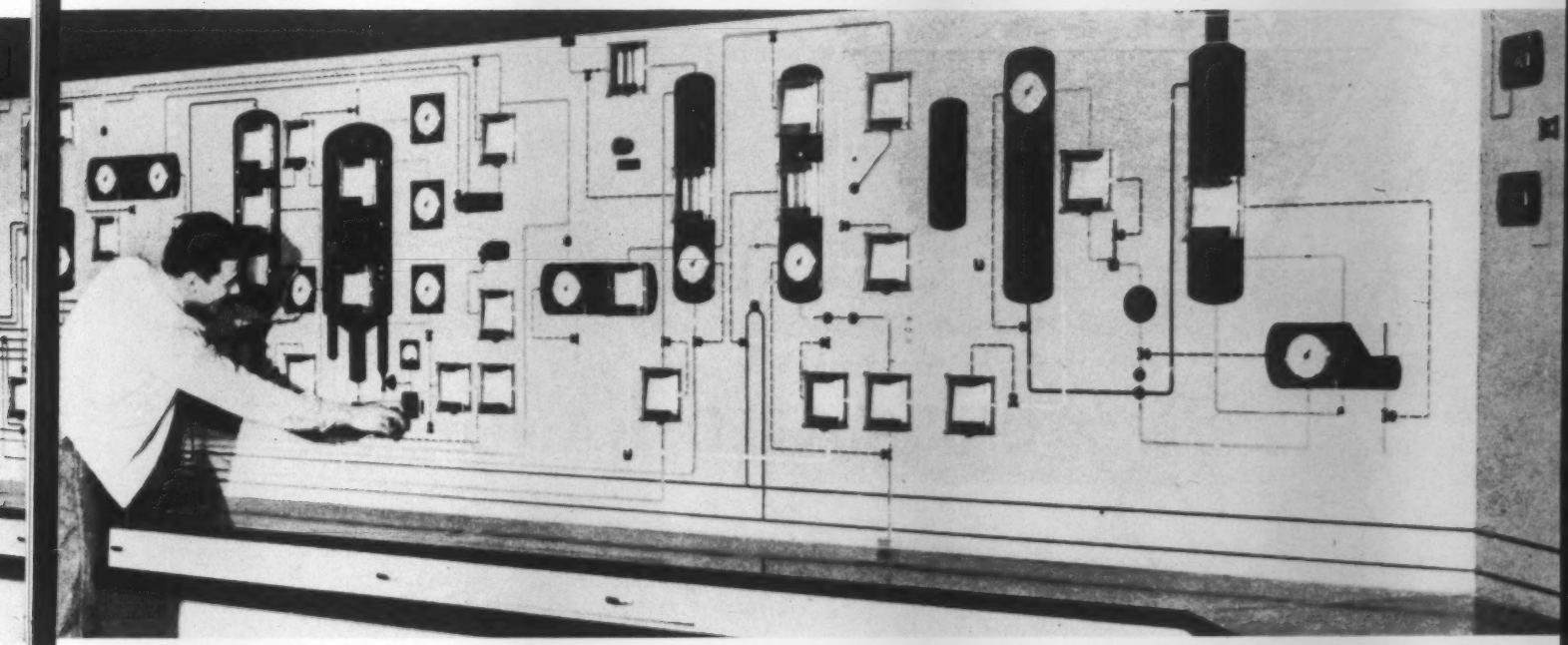
To fill an ever increasing consumer demand for gasoline, diesel fuel, and fuel oil in the upper mid west region, the Lummus Co. was commissioned to design, engineer and build the refinery described in the accompanying illustrations.



2 Graphic panel 35-ft long designed and built by Minneapolis-Honeywell Regulator Co. uses over 80 Tel-O-Set instruments mounted at their proper places in the flow diagram to give the three operating engineers a comprehensive view of every phase of the process, and enable them to alter conditions of pressure, temperature, flow and level according to the varying needs of the moment without leaving the control room.



3 Pressure regulation in the reactor is by means of cascade control system. Differential cell detects pressure difference between reactor and regenerator and transmits signal to recorder controller on panel whose output positions the set point of a pressure controller which is measuring pressure in the regenerator. The pneumatic signal of this second controller is transduced into an electrical signal which acts through an electronic bridge and relay to control forward and reverse line starter on an electric motor driven slide valve in the regenerator stack to assure a constant one-way flow of catalyst to the reactor.



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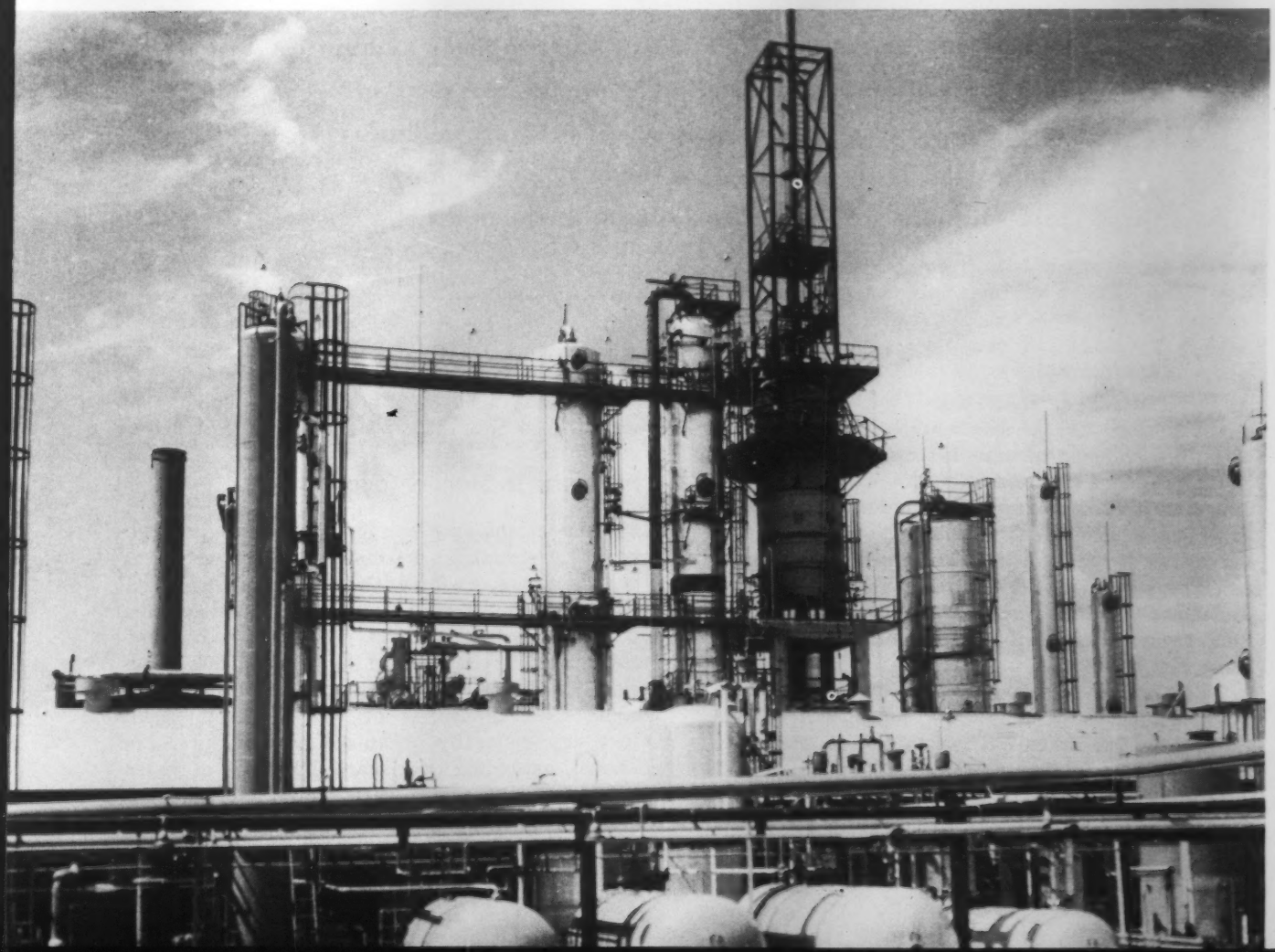
Below—Crude tower, main fractionator, reactor, regenerator and catalyst hopper are the heart of the refinery. Cascade control system measures and regulates temperature in the reactor. The pneumatic signal from this panel unit is fed to a second recorder controller to position its set point. The system records the flow of air to the spent catalyst riser to the regenerator and regulates the circulation of air at the level set by the temperature control system.



By CHARLES E. KRAUS
President, Kraus Design, Inc.
Rochester, N. Y.

MANAGEMENT'S STAKE IN AUTOMATED HANDLING

In order to make full use of the advantages of automation, both management and engineering must have a general understanding and appreciation of the problems and applications of automatic handling. Here the aim is to introduce the subject and orient it relative to automation as a whole. Details on specific phases and examples of problems and solutions will be dealt with in subsequent articles

AUTOMATED HANDLING of workpieces is a major part of the automation era everywhere in evidence in manufacturing today. Many of the problems of automation are problems of handling and to some extent automation is limited by handling possibilities. Frequently automation is narrowly defined as the mechanized automatic handling of parts between machines. However, it is generally being realized that the word automation, as a contraction of automatic operation, is becoming accepted as descriptive of many things in addition to merely handling of a product or workpiece.

Essentially automation means operator elimination, particularly for repetitive jobs such as loading, unloading, or transferring workpieces from operation to operation, and results in combinations of operations in single machines or a linkage of machines into integrated production units.

Where It Stands Today

Because mechanized handling is such an intrinsic part of automation, an understanding of where it stands today, its breadth of scope and general design philosophy can be had by understanding automation's position today. The history of manufacture can be considered as divided into four periods up to the present time. The primeval, extending over thousands of years, was a period before any generally organized manufacture. The medieval, extending over many hundreds of years, was a period of crafts with manufacturing done by craftsman and apprentice. The medieval period

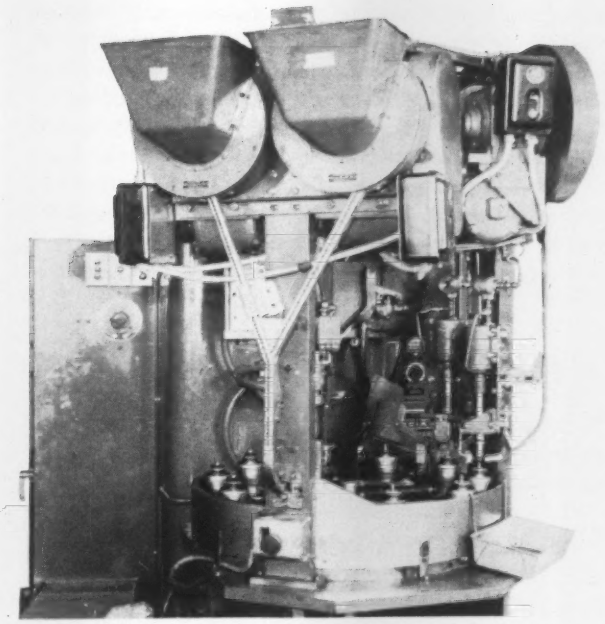


Fig. 1—Automated handling mechanisms applied to this standard welding machine enable four different pieces to be automatically handled and positioned

is generally considered to have ended in the industrial era brought about by the development of the factory. As the volume of manufactured goods accelerated, a new method or concept of manufacture emerged about the turn of this century—that of the assembly line or production line. Essentially this method differs from the segregation by process or type of operation, and uses a sequencing of processes and operations as required by each article of manufacture.

Now, still under the impetus of the accelerated volume of manufactured goods, automation, the new method or concept of manufacture, is developing into a dynamic era of production. Involving as it does the use of automatic handling and processing, automation increases the production of the human operator by relieving him of many repetitive handling and processing operations. In a sense it is a transition stage between manual control and the completely automatic factory which may well develop into a commonplace reality at some date in the future.

Increasing mechanization of manufacture does not supplant previous manufacturing means when viewed as a whole. There may be displacements, a reshuffling of facilities, but because the new methods are spawned by increased manufacturing tempo, their substitution has not cut down on the required labor force. This is a very important point, as it has a tremendous effect on the stake of labor and the philosophy of management. The long run net effect of all mechanization appears to be a decrease in unit costs, an increase in volume per man hour, a general increase in the standard of living, a definite shortening of working hours but, *not* a reduction in the labor force.

CHARLES E. KRAUS, founder and president of Kraus Design, Inc. is an outstanding authority on automatic parts handling equipment and has been instrumental in the design of many modern automation installations. As a graduate of the University of Michigan with B.S. and M.S. degrees in mechanical engineering, he served there as a metal processing instructor. Mr. Kraus was director of research and development at Ingersoll Milling Machine Co., Rockford, Ill. and was sales engineer for Consolidated Machine Tool Co., Rochester, N. Y. prior to organizing the Kraus Engineering Co., predecessor of the present corporation. He holds patents on a number of mechanical inventions.

▶ Where It Is Applied

Mechanized handling of workpieces is a fundamental part of automatic processing. Its area, scope and technical problems are generally those of automation. Whenever second operations are required the question of handling between operations must be considered. Parts may be either transferred directly from operation to operation without going into bulk state, or go into temporary storage to the next operation. Both methods may be performed either automatically or manually. It is convenient although not generally accurate to divide applications of parts feeding into certain classifications: manufacturing or processing, testing and inspection, and assembly.

▶ Manufacturing or Processing

The selection of automated methods sometimes involves basic decisions that effect both quality and design. This is particularly true where quality can be improved by deburring, cleaning, plating or heat treating between operations. An illustration may be any of numerous examples of electrical contacts or lugs. Commonly progressive die products, they are often assembled to strip or wire directly from the die. Raw edges and lack of plating on edges, if made from tinned stock, reduces the quality. Tumble deburring followed by plating and then assembly by parts feeder greatly improves quality. In *Fig.* 1 is illustrated a standard welding machine equipped with automatic handling and positioning mechanisms.

▶ Testing and Inspection

With manual handling of parts, each operator is an inspector. Parts that vary from standard in any way that would prevent proper operator positioning are discovered and rejected. In many cases

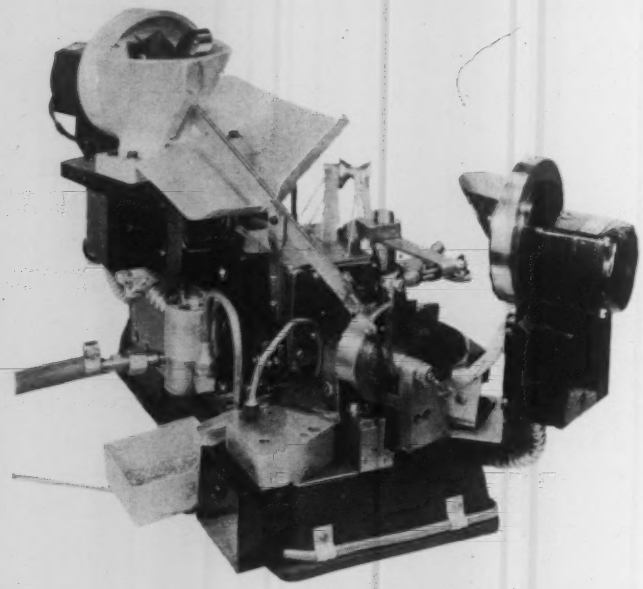


Fig. 2—Optical screws and washers are hopper fed and automatically assembled in this small automated handling device

management is unaware of the effect of this operator inspection until automation is applied. For many reasons faulty workpieces must be found and eliminated at the point they are produced. It follows that much more extensive and 100 per cent inspection by automated means are indicated whenever automation is applied later to the pieces.

Two automation methods are possible; one by check or test stations on the part producing machine prior to bulk conditions, or during transfer from such a machine; and the other by special inspection equipment stations fed by automatic part feeders. The first of these methods is particularly desirable if the inspection is for missed operations. Instantly detecting a broken drill and stopping the machine usually saves considerable scrap or expensive salvage. If the inspection is for close dimensional tolerance, the second method is usually best as in the case of size inspection of ground balls or rollers.

Assembly of Components

Handling for assembly is rather broad, particularly for bulk parts, as the assembly of one part to another is often only one step in many operations applied to the second part, or the assembly of two or more parts is only a small subassembly. The easiest and most common of these applications is the feeding and assembling of screws, *Fig.* 2, and rivets. Complete automatic assembly of products having numerous parts is a type of automation receiving increasing attention. Parts feeders are a necessary part of such units, but most present assembly applications still use operator assistance for some one or more operations. Perhaps it should be mentioned that assembly units involving many components are certainly the most vulnerable to part accuracy troubles, and difficult to perfect. Even though apparently unnecessary, experience has shown that at least one operator is often advisable on complicated and costly machines. It usually works better if this operator has a function to perform as this tends to keep attention to the job.

Packaging and Distribution Savings

It is pointless to attempt to compare or even, sometimes, to differentiate between the three general classifications of applications just mentioned, as numerous examples of automated equipment can be given where processing, assembling and both testing and inspection are all performed on one machine. There is one big field of application, however, that is largely divorced from the strictly manufacturing types, though commonly performed at the manufacturing plant; this has to do with such operations as counting, labeling and packaging of completed products or assembly to customer products. Much has been accomplished to reduce manufacturing costs without attention to distribution costs. The percentage of costs going into distribution, therefore, has been rising. By shipping in bulk and counting or labeling and packaging in strategically located subplants, considerable savings are sometimes made and this application field for specialized automation equipment is expanding rapidly. Also expanding rapidly, is the field of automated units either sold or rented by producers to their customers, for the use or assembly of the producers product. Such units range in complexity from rivet or snap attaching units, for example, to highly complicated card sorting or paper bottle filling units.

Questions For Management

In the final analysis the object of automation is to reduce the net cost per piece. Automated equipment saves direct labor, increases production rates, conserves floor space and reduces inventory. Obviously, if the amortization period is long enough, automated equipment will always pay off, if it is not obsoleted by design changes. Management therefore has two important initial questions to answer in determining when to apply automation. An inflexible attitude on amortization can easily put a company in a poor competitive position, costwise, with competitors taking a more liberal view. Planning an automation program should start early. Much of the equipment is special and requires special design and plenty of time for elimination of bugs. Estimating costs of producing such equipment is extremely difficult, and management must allow liberal factors of safety. In many cases, reputable producers of such equipment may not quote firm figures on the more

complicated units. Many in management have learned w..y when they have built their own equipment.

While it is probably true that the trend to automation is due to h.gh production levels, it is fallacious to assume that automation, and particularly automated handling, is practical only for the higher production rates. Replacing an operator doing one operation a minute is often easier than replacing one doing sixty operations a minute, and the savings are just as great. It is possible for management to overlook opportunities for great savings and choose applications with many problems, simply because of preconceived ideas of when automation should be applied.

▶ Problems in Automatic Handling

In all of the several fields of application where mechanical handling of parts is found, there are a number of different types of problems that are encountered. These problems can be divided into two broad categories. The first category is those problems which are intrinsic to the piece rather than the equipment, the design or characteristics of the workp.ece which may affect handling; whereas t.e second category is the mechanical problems of equipment design and parts handling that may be posed by the workpiece because of required feed rates, orienting and chuting problems or inserting and positioning requirements of the process. The intrinsic characteristics of the workpieces involved create problems not only in the parts feeder, but also in any application of automation which, of course, includes special automatic equipment to perform certain operations on the workpiece. This type of equipment is expensive to produce and requires considerable time and effort to get all operating troubles cured, so it is obvious that the design of workpieces for which such automatic equipment is to be built and developed, should be pretty well frozen. As a rule, this does not mean that design progress is too greatly handicapped. It merely means that the workpiece to which automation is applied, should be thoroughly perfected in itself so that minor changes are not encountered during the period the automatic equipment is being built. It follows too, that the design of the workp.ece should be correlated with the problems of t..e special machine and handling equipment. Very often minor changes in physical shape, changes in material or finish specifications may greatly simplify automation problems and frequently decrease capital expenditures.

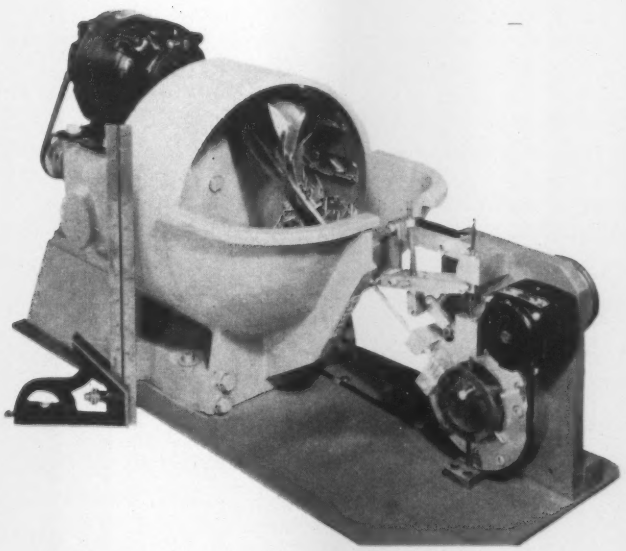


Fig. 3—Orienting parts for proper feeding may be essential to the production process. Here cylindrical pieces having one end rounded and the other flat are automatically delivered with the rounded end leading

Besides the design, as it affects physical shape, material, and finishes, other problems which are intrinsic to the workp.ece itself, are the rejection of bad parts, presence of oil or chips or foreign matter and general problems of uniformity which may be present. It is one source of considerable expense and difficulty in any automated equipment to have to handle pieces which do not conform to the tolerances for which the equipment was intended. Such malformed pieces may be incomplete parts such as bar ends or double stamped pieces in the case of press products, or missed operations, which may occur on screw machines, or accidentally damaged pieces which may be produced almost anywhere along the line prior to the specific operation involved.

An additional problem in the intrinsic category is the stamina of the piece itself. When pieces are to be handled in the bulk or by transfer means variously clamped or unclamped, tumbled and rolled, a certain minimum amount of durability is required. Often times this does not only mean that the piece should merely resist be ng broken or chipped, but that it be designed not to have extremely fine finishes or thin sections which may be bent or microscopically damaged.

Problems that are primarily mechanical in nature and more peculiar to the mechanical handling of parts, have to do with required feed rates, chuting, transfer and orienting problems. It is particularly t.e latter which frequently indicate desirable changes in the design of the pieces. Some required orientation of the workpiece may be greatly simplified by changing a profile or adding a notch, or may be completely eliminated by making the piece symmetrical in one or more planes. *Fig.* 3 illustrates a mechanism that orients a cylindrical piece that has one end rounded and the other flat. Orienting problems are sometimes complicated by the fact that orientation cannot be maintained while the piece is being chuted or transferred from the parts feeder and positioned in the machine. Frequently, in order to chute the piece successfully, certain orientation positions are required which may not be the preferred position for application. Therefore, one of the problems of automatic parts handling equipment is in auxiliary orienting devices which may be an integral part of the inserting or positioning mechanisms.

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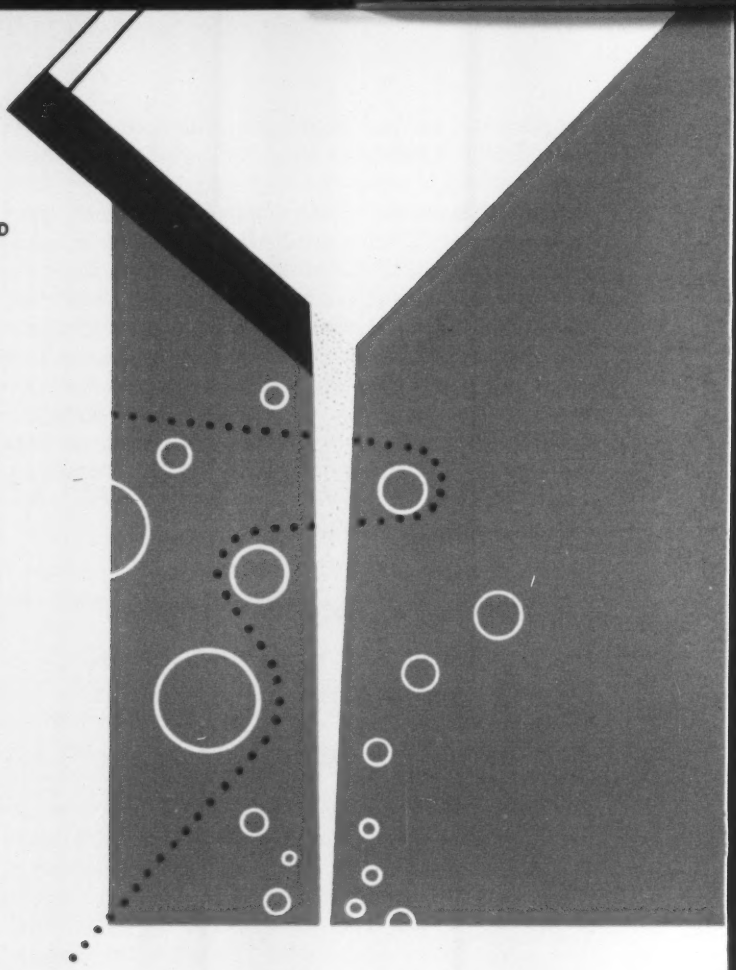


IMPROVING PACKAGING ECONOMY WITH WEIGHT CONTROLLED VOLUME FILLING

High speed packaging of varying density product involves problems of accurate measurement and rapid adjustment

A TREMENDOUS increase in the production of granulated soap and detergent products in folding cartons has developed entirely new demands on packaging machinery and supplies. Some of us can remember when production speeds at 30 cartons per minute were considered to be phenomenal, two or three operators being required to complete the operation through to the shipping case. These times, production speeds up to 260 per minute with two operators is almost commonplace and readily available on equipment built by various manufacturers of packaging machinery. Even 300 per minute has been efficiently maintained on the latest type machine.

Challenge To All

Such speeds, coupled with high efficiency, could not have been attained without close cooperation between the machine manufacturer and engineering personnel of some of the larger companies in the soap industry, the carton manufacturer and the suppliers of glue and other packaging accessories. Obviously, every unscheduled stop of the production line at these high speeds becomes very serious, not only because of lost production but waste of cartons and the disposition of the flow of product running to the filling machine in a never ending torrent. Hence, high speed demands high efficiency which in turn requires a high degree of machine perfection. Huge production requirements, together with a trend towards some standardization of package construction and size, has made it practical for the machine manufacturer to specialize on the development of equipment for the particular requirements of this industry with a view to reducing packaging costs to the utmost.

The economy of high speed with its savings in floor space, labor and capital investment is obvious, but caution must be used lest other important cost factors such as production quality, efficiency, spoilage, maintenance and accuracy of weight are not sacrificed to speed, thus nullifying its advantages. Speed is essential but so too is minimum waste of product and packaging materials and the quality of the finished package.

To make high machine speeds practical it is essential to reduce to a minimum the required number of operations to produce a finished package and to perform this operation, so far as possible, with smooth running continuous-motion mechanisms. This cannot be done without sacrificing to a

considerable extent such factors as flexibility, range of package size, variety of products handled, adjustability, etc. Furthermore, it is necessary that cartons, glue and product, in short, all materials that make up a finished package, be of uniform high quality.

Basic Considerations of Design

A most efficient solution of the machine problem has been the development of a combined integral machine which feeds and sets up the carton blank in continuously moving pockets, seals the bottom, volume measures the product, fills the package and then closes the top. By this means a finished high-quality siftproof package is produced without complicating the operation by frequent transfers of the carton from one mechanism to another.

The filling of the package at speeds up to 300 per minute presents a difficult problem. A ton of product must be handled every five minutes and accurately subdivided into 1400 or more packages so that each package will contain just the right amount of material. Short weight must be eliminated and overweight at high production rates is prohibitive in cost. To measure the exact fill for each package by multiunit weighing apparatus presents mechanical problems when applied to high-speed continuous motion machines of the type described. Volume measuring the fill has therefore been exclusively used on machines of this type as being simpler and capable of higher speeds.

A turret on which a series of 10 or 12 adjustable measuring flasks are mounted continuously rotates in time with and above the carton pockets of the packaging machine. The flasks discharge the measured volume of product into the bottom sealed packages as they travel in a semicircle around the end of the machine. Filling apparatus of this type has proven satisfactory, however, only when the product density can be held sufficiently uniform to insure reasonably accurate weights. While volume filling contributes to simplifying the problem of higher speeds, it creates a possibly more critical problem in the control of declared package weights.

Package weight, when volume measuring methods are used, is subject to two principal errors. First, the flask to flask variation or error inherent in the process of uniformly filling, leveling off and discharging each individual flask and second, error caused by changes in product density or weight per unit of volume. A high degree of mechanical perfection of the filling apparatus has minimized the former and, although research and development of manufacturing techniques by the soap manufacturer has reduced the latter, it is still the greatest cause of weight variation. It is the second type of error that we are chiefly concerned with.

Machine Operating Principles

During the past year a new machine, *Fig.* 1 has been installed in one of the larger soap plants which not only has a speed potential up to 300 packages per minute, but greatly reduces this second type of error by using a method of automatic weight control applied to volumetric measuring. While it is theoretically possible to compensate for density variation by manually adjusting the flask volumes, this is too slow a procedure to be practical at high production speeds and it is always subject to the uncertain human element. By the time a package has passed through the machine so that it can be removed and its contents poured out and check weighed, so much time has elapsed after the actual filling operation that a change in product density may have occurred in the interim. The check weighed product may no longer be a true

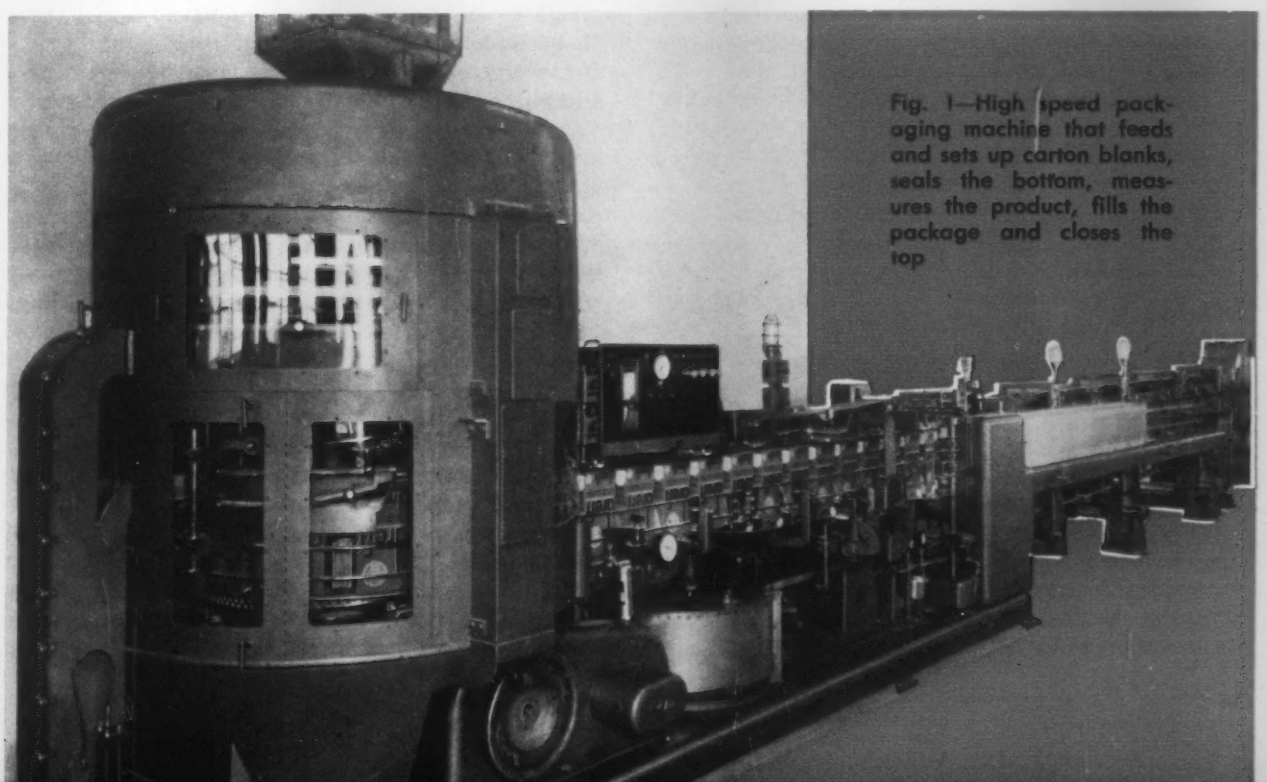


Fig. 1—High speed packaging machine that feeds and sets up carton blanks, seals the bottom, measures the product, fills the package and closes the top

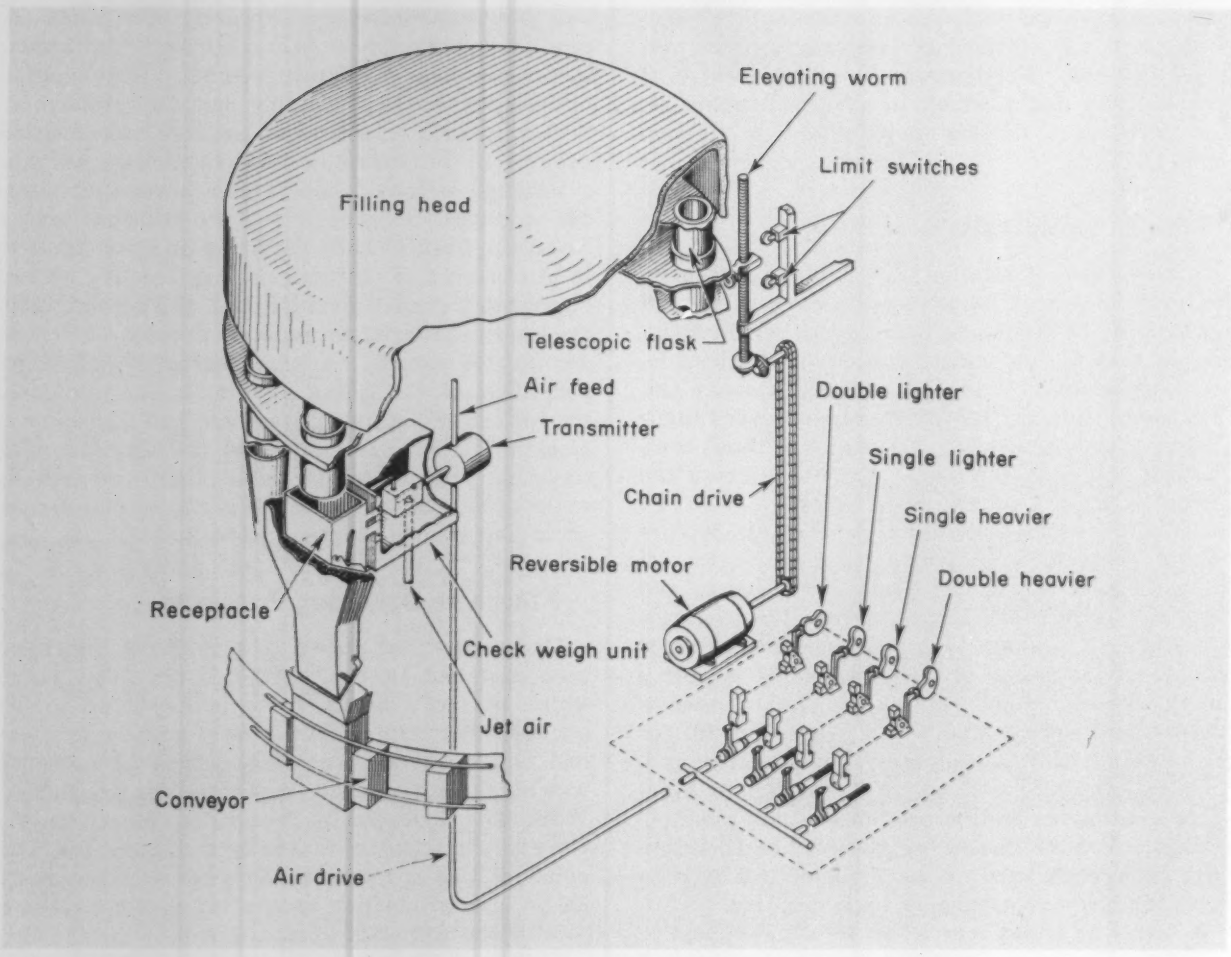


Fig. 2—Diagram of weighing and correcting system showing check weighing device. Control device and volume adjusting device incorporated in rotating filling head

sample on which to base a change in volume adjustment. Density may have changed in the other direction so that more harm than good will result from such a procedure. For manual correction to be practical, product changes, therefore, must stay uniform for relatively long periods of time. The higher the operating speed, however, the more rapid do changes in product become thus making manual control increasingly impractical.

Continuous rapid automatic check weighing directly at the point of fill followed by an immediate automatic correction of flask volume when the product changes was incorporated in this machine and has reduced package weight variation caused by density changes by at least one-half.

The apparatus consists of an accurate quick-acting check weighing device mounted directly below one of the 12 measuring flasks and continuously rotating with it. The flask discharges the product into the weighing device where it is rapidly weighed and then discharged into the package below. The other 11 flasks discharge into their respective packages in the regular manner. When the variation in weight of a checked load exceeds predetermined allowable limits, automatic correction of all the flask volumes by a uniform predetermined increment immediately takes place during the next revolution of the 12-flask turret.

One revolution of the turret is required for check weighing and another revolution of correction, thus the complete operation is performed continuously for every case of 24 cartons or approximately 10 to 12 times per minute. The apparatus is also provided with a recording device which graphically records the checked weight of every 24th load on a continuous paper tape, and indicates the number and duration of machine stops. The correcting device is provided with limit stops so that the flask volumes will not be increased for very light product to such an extent as to overflow the package and decreased for very heavy product so that the fill level will fall below prescribed package outage limits. A red warning light is flashed each time the limit stops are actuated. The uncorrected weight is recorded on the tape thus furnishing a visible record of the number of times such extreme product variations occur.

The weight control apparatus, *Fig.* 2 consists of the following three main devices: (1) A check weighing device, (2) a volume adjusting device which by means of a reversible motor changes the volume of all 12 measuring flasks simultaneously,

and (3) a combination weight recording and control device which in accordance with a signal from the check weigher actuates the volume adjusting motor.

Check Weighing Device

The invention of the Pneumatron Weighing Head has made it practical to mount weighing apparatus on a continuously rotating turret without loss of sensitivity and reliability as would be the case with the conventional type of knife edge scale beam. The receptacle which receives the charge to be check weighed is rigidly mounted to a stiff cantilever structure of parallel spring bars. The deflection rate of the system is very small, in the order of 0.002 to 0.003-inch per ounce and damping apparatus is used to absorb vibration. The structure is not only rigid but very light which, coupled with the small deflection rate, reduces momentum to a minimum thus making the scale highly responsive and rapid in action. It closely approximates what might be termed "pressure weighing".

The deflected position of the beam is a measure of the exact weight in the receptacle hence this position must be very accurately and reliably gaged. This is done by the use of the well known "air gage" principle commonly used to measure or gage machine parts. Minute changes in the deflected position of the scale produce rapid and large changes in air pressure in the order of a pound or more per square inch for each sixteenth of an ounce change in weight. Thus there is available something relatively powerful for actuating the control device. These varying air pressures which correspond to weight variations are fed as a signal to the control device.

Volume Adjusting Device

The measuring flask adjusting mechanism is actuated by an electric motor which increases volume when running in one direction and decreases volume when reversed to the opposite direction. The length of time the motor runs governs the amount of volume correction. The corrections are always made in increments of the same value. There are four such increments, one small increment and one larger increment on the light side and a small and larger increment on the opposite or heavy side. The flask to flask variation inherent in the mechanics of volume measuring is first determined by a trial run with the weight adjusting motor switched off and with product of uniform density. This is automatically set up as a normal scatter pattern on the recording tape, and bounded by upper and lower limit lines. So long as the density of the product stays uniform, all weights will fall within these two limits which in normal practice may be from plus or minus 3/16 to plus or minus 3/8 of an ounce depending on the weight and type of product being handled. Whenever the density changes, however, either to the heavy or light side, the normal scatter pattern does not stay within the limit lines but drifts up or down by as much as ½ to even one ounce in actual practice. It is the function of weight control to correct this drift in weights.

The automatic control is now turned on. Whenever a weight falls outside either limit the weight control device actuates switches which operate the volume adjusting motor. A weight on the light side actuates the "single light" increment and a weight on the heavy side actuates the "single heavy" increment.

If the product density is changing so rapidly that the single corrections do not adjust the volume rapidly enough to quickly bring succeeding weights within limits then the "double light" or "double heavy" increments are automatically actuated. The amount of the four correction increments can be independently adjusted but once adjusted they are always uniform in amount. Each increment device flashes a small light on the control panel giving visible evidence of what is taking place.

The weight control apparatus was first designed to make use of "statistical control methods" whereby a group of five weighings was averaged and a correction based on this average was made. It was found, however, that density variation was often so rapid as to make this method too slow.

Recording and Control Device

This apparatus, *Fig.* 3, receives the air pressure signal from the check weigher and translates it into the proper correction increment corresponding to the actual measured load which was weighed and then by means of timed electrical switches controls the action of the flask adjusting motor. There is a switch for each of the four correction incre-

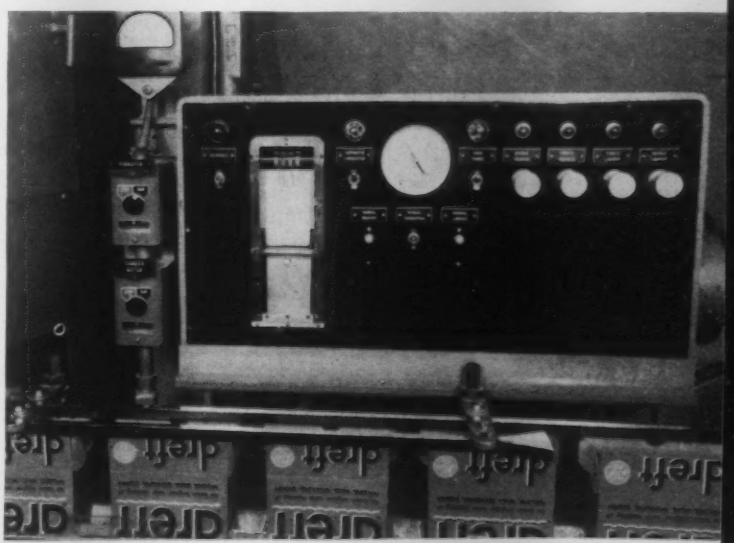


Fig. 3—Control and recording station with switches, lights, controllers and meters to set and reveal the operating conditions of the machine

ments and each switch is actuated by air pressure. The lightest weights give the lowest air pressure and the heaviest weights, the highest pressure. Each switch is adjusted to actuate at the particular pressure corresponding to the weight for which the desired correction is to be made. The length of time any switch stays in the "on" position governs the number of turns of the flask adjusting motor and hence the amount of correction. This length of time is regulated by cam action and is adjustable.

A ribbon of heat-sensitive recording tape, *Fig.* 4, is slowly and continuously fed through the recorder by a small electric motor. A spring loaded arm carrying a heated pen filament is actuated by an air pressure bellows so as to travel transversely across the tape from the light to the heavy side without touching it. As the check weigher deflects to weigh the load the air pressure rises and traverses the pen across the tape until the weigh beam comes to rest and the air pressure remains constant and the pen ceases to travel. The pen is then depressed to touch the paper tape and imprint a small dot thereon. The transverse location of the dot indicates the actual weight of the load. The greater the deflected position of the beam, the heavier the load and the higher the pressure, the greater the distance of pen travel. The calibration scale of the tap is readily adjustable by varying the spring leverage of the pen arm. It is commonly set at a scale of approximately one inch per ounce so that sixteenths of an ounce can be easily read. The recording device stops and starts with the packaging machine, but the tape feed runs continuously. Machine stops are thus indicated by blank intervals on the recording tape. The length of the stops as well as the number of stops are thus recorded.

Flexibility and Automatic Control

The weight control apparatus is supplied with manual control buttons so that the motor which adjusts the flask volume can be manually operated in either direction and for any length of time. When starting up the packaging machine, the weights can therefore be quickly adjusted by large or small amounts to rapidly bring the scatter pattern within the limit lines. The machine may also be run with the automatic correction inoperative in which case it functions as any normal volume measuring packager.

If the machine is run without cartons, the discharge of product from the measuring flasks is automatically stopped to avoid spillage and waste of product. The weight control must then be automatically stopped, otherwise it would throw the flask volume out of correct adjustment because the check weigher would be receiving no load and hence continuously correcting the same as for light loads.

An air gage is mounted on the control panel and shows the varying air pressures corresponding to the checked weights of the product. The panel also contains the four lights which indicate the operation of the four correcting implements.

Economic Reasoning

Heretofore, the soap manufacturer has logically reasoned that if it costs him more to package his product with accurate weights than to give away a little overweight, then slightly over filling the packages would be more economical. This reasoning depends, of course, on the amount of overweight he must give away as against the increased cost of obtaining accuracy. With the weight control device, no additional packaging costs are incurred other than the initial capital investment. Speed, floor space, number of operators and efficiency stay the same and yet the weight inaccuracy of fill can be reduced conservatively by one-half. If weight variations of plus or minus $\frac{3}{4}$ ounce can be reduced to plus or minus $\frac{3}{8}$ ounce on a 20-ounce package, the resulting savings in product is obvious for the huge productions involved.

Theoretically, of course, we have the eternal controversy between the two schools of merchandising; should we sell so many ounces of granules or so many cubic inches of granules? Should we strive for a marketable package only, regardless of weight, or should we have correct weight, regardless of fill? Pehaps automatic weight control applied to volume filling will resolve the dilemma by combining the principles of both methods. At least it is a comforting thing to have a continuous automatic control over package weights and a visible registered record which by showing weight variations also shows product density variations, thus stimulating the approach to that ever to be desired goal of product uniformity.

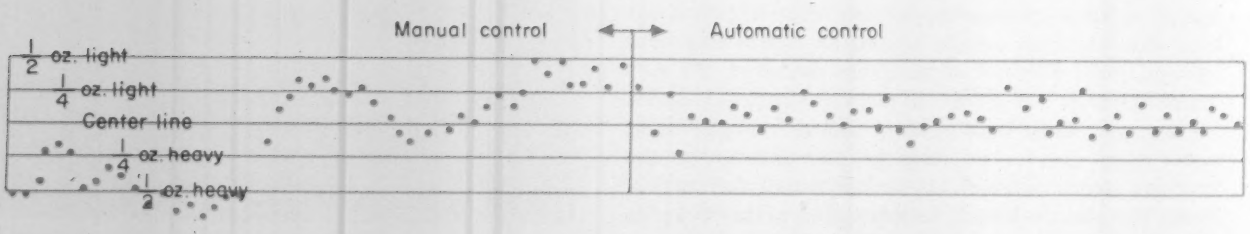
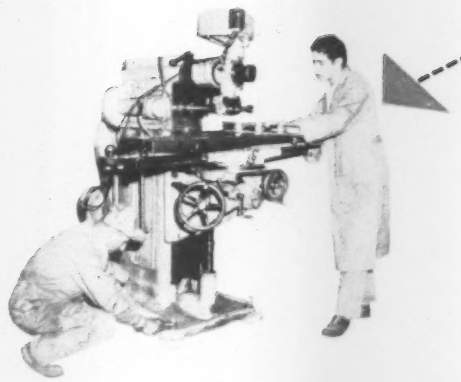


Fig. 4—Sketch of heat-sensitive recording tape shows typical readings from both manual and automatic adjustments of fill

MODERN MANUFACTURING PLANNING UTILIZES

MACHINE MOBILITY



Mounts that permit easy removal of machines for repair or rearrangement offer automatic production line economies to small lot-type production, and permit "off-the-floor" maintenance service

By EDWARD A. JOHNSON
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IN THE ERA of the automatic factory, already upon us, the age-old problems connected with machine manufacturing have become intensified. Ever since the distant days when production first moved out of the home and into the factory—what the text-books call the industrial revolution—idle machines have always spelled trouble in the form of lost time, idle men, disruption of work schedules and missed delivery dates. And, today, our factories are so complex that a single machine "down" causes a pyramiding chain reaction of secondary problems—each one more serious than its predecessor and each adding its bit to the total confusion.

When a machine breaks down in a typical modern factory it causes a backing-up of work in process, material "floats" between work stations become congested, operators stand around waiting for something to do—until finally a carefully planned production line is completely disorganized.

Yet, just as the machine age created its own special problems, so did it make possible the solution of those problems. Quite often a new and dramatic approach can be made, based on technological experience and the machine "legacy" of those who preceded us.

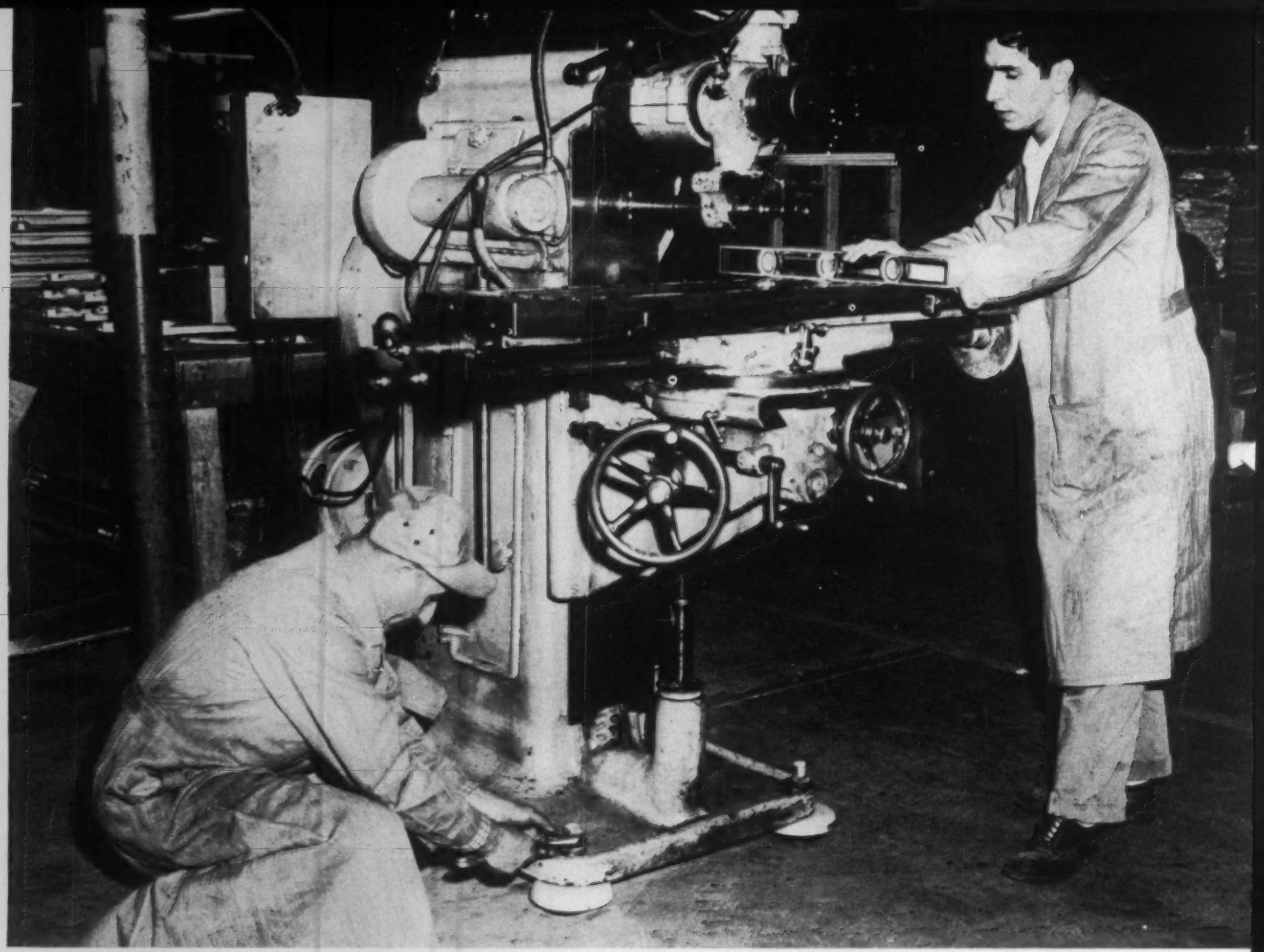
As an example, consider the problem of repairing industrial machinery. Here at the Barry Corp., as in so many other companies, for a long time we did our repair work at the machine location, on the production floor. After running a number of comparison time studies, however, it was observed that in many cases this work should be done away from the production line for best results. And it isn't difficult to understand why: out in the plant physical space is at a premium. The repairmen's best efforts are hamstrung because of lack of room, and because of the general confusion that is generated by a machine breakdown. People gather about to watch, and work on nearby machines slows down or halts entirely.

To overcome this condition a procedure of *centralized repair* of machines was instituted. The solution is as simple as it is effective. To put it briefly, machines are now supported on mountings which require no floor belts. When a breakdown occurs fork lift trucks shuttle the machine to and from a centrally located repair department where work can be done without interference. In this instance, special leveling mounts enable the removal of equipment from the floor without delay. Machines can be replaced or re-positioned without losing valuable time lagging or cementing them to the floor. Such machine mounts were unknown five years ago.

The lesson learned in our repair department can be extended to cover the entire concept of what might be termed "plant mobility." In the modern factory, it is possible to consider several methods for keeping production lines mobile.

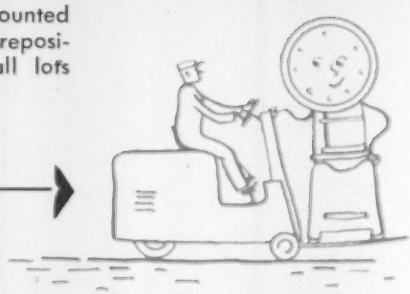
Plan Flexible Production Lines

When a new assembly or production line is set up, changes are needed almost from the outset. A



Instead of moving workpieces to scattered-permanently mounted machine tools—equipment on mobile mountings can be repositioned and quickly leveled for line production of small lots

MACHINE MOBILITY



machine may have been badly placed, or perhaps available space was not utilized most efficiently. A plant layout that looks fine on the drawing board frequently develops a number of bugs when translated into reality on a factory floor.

The same sort of thinking applies when a product is modified, or changed completely. A plant is not mobile unless machines can be moved about rapidly and easily when the factory stops making "left-handed widgets" and starts producing "right-handed friskets." In both situations—starting up a new line or revamping an existing one—putting machines on mobile mounts would provide the desired flexibility.

For one company the problem of keeping production lines flexible is simplified by keeping a file of alternate plant layouts on hand. This firm makes farm machinery—a field where competition is keen and where current models are quickly obsoleted and replaced by newer ones. At one time a model change brought much aggravation and lost man hours. But by planning several different production lines in advance, and providing for sequences of operations commonly encountered, a new setup can be arranged in a fraction of the time formerly required. All machines are placed on industrial mountings that eliminate lagging and bolting to the floor.

▸ Centralize Major Maintenance Work

If machines are mobile, the average maintenance job becomes a repair job—at least to the extent that the work is done at a central point away from the production line. Of course, any routine maintenance which does not interfere with production, i.e., periodic lubrication, will still be performed right at the machine. On the other hand, a job like substituting a motor in a machine drive in

order to do a major overhaul should properly be handled in a centralized "machine garage."

This system works especially well if entire "replacement assemblies" are kept in stock. In our shops a major cause of delay in getting machines back into action was the search for replacement parts. Now we employ a system of packaged replacements which, as the name suggests, means keeping a number of crucial assemblies on the shelf ready to be installed.

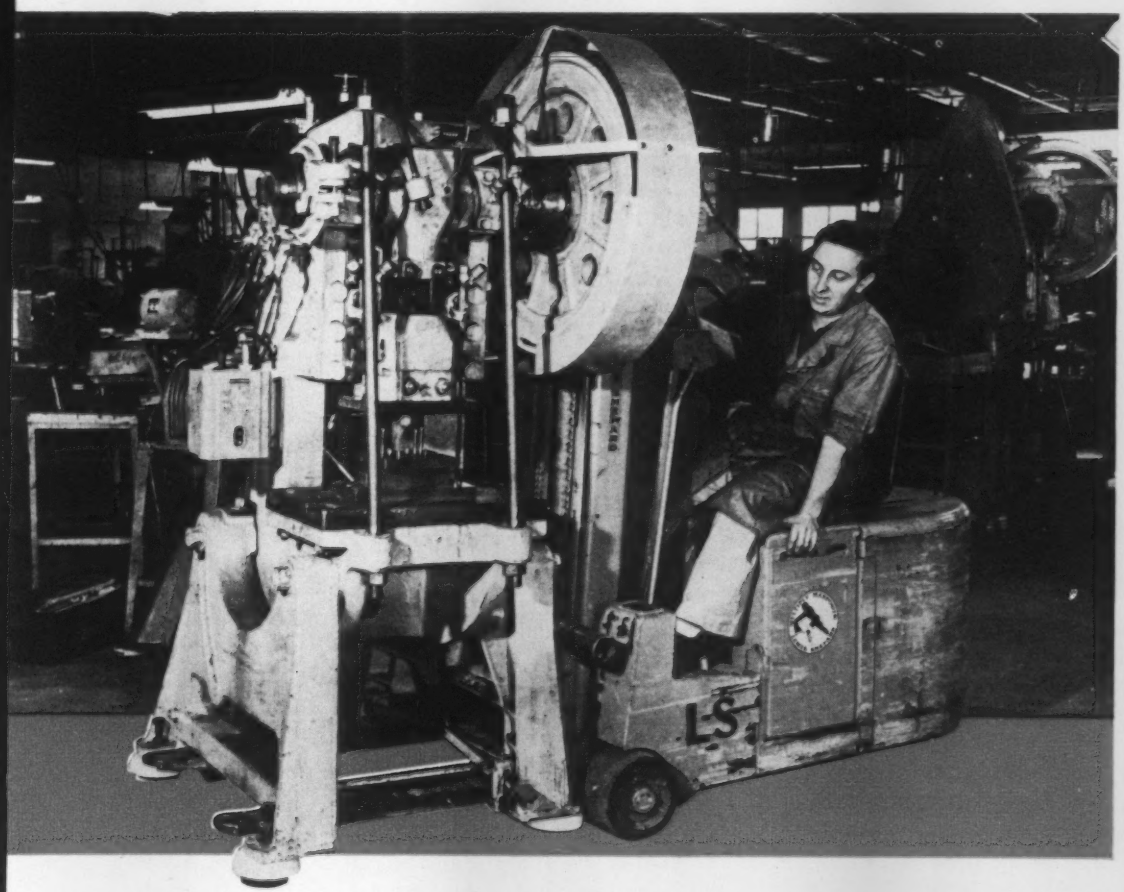
▸ Bring Machines to the Work

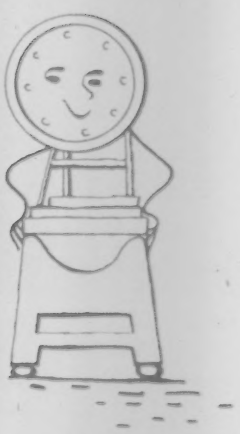
Recently we conducted a survey among some 10,000 executives in the metalworking industry. Among other things we wanted to know whether their plant machinery was being used to full capacity. It was surprising to find that many companies, both large and small, are still bringing men to machines, when it should be the other way around.

Operations in one small metalworking plant are typical of this attitude. In this plant, a metal roll marking machine was located in the center of the floor for all to use, and men came to it from all over the shop. The loss in time and production was two-fold: the machines the men left were standing idle, and the men themselves frequently waited in line for a turn at the marking machine. Had the machine been on mobile mountings it could have been spotted around the plant according to the demands of work flow. The total man-hour savings would reflect the increased worker efficiency, better morale throughout the plant, and less work-in-process at any given time.

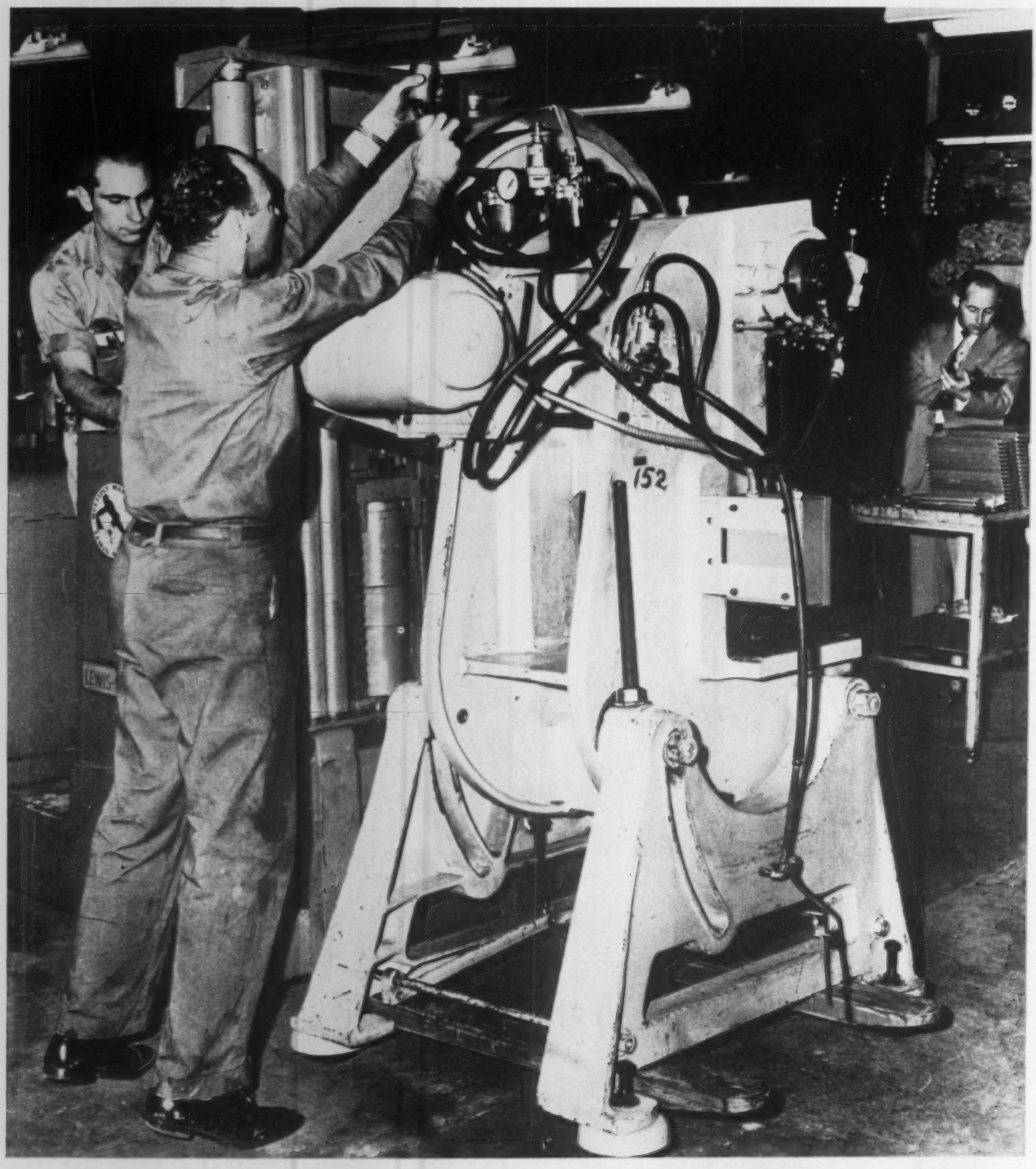
▸ Consider the Plant As a Unit

Our application engineers had the pleasant experience of saving many thousands of dollars—the purchase price of a machine—for a leading manufacturer of electrical appliances. The company already owned seven machines of this type, one just recently purchased, and still another one was being requisitioned. Purchase of the new machine was held up by management until a study of machine





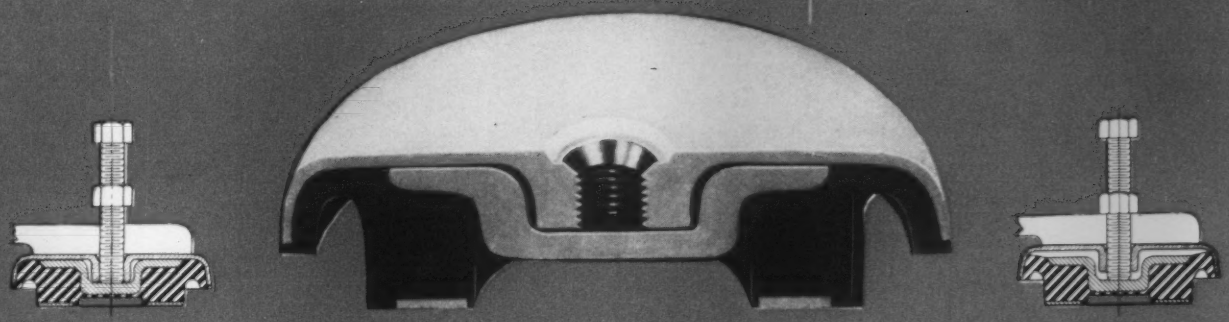
Mobility enables flexibility of layout. Presses of this type formerly had to be bolted to the floor or they would "walk off the job." Now portable, the machine is readily moved to another production line or to repair zone



Ease of relocation and speed of hook-up offer greater plant-wide machine utilization potential. Machinery with open capacity can be readily set up in another department whose work loads require additional equipment

loadings could be made on those already installed in the plant. The result of the study came as a shock to all: *not one was being used as much as one full day per week.*

Admittedly this is a rather extreme example. Yet it is characteristic of a common error in many plants. Management often limits the use of a specific machine by thinking in terms of rigid "departments". Machines are bought on a department basis and used the same way. This in spite of the fact that where a company has a great many departments, even the plant engineer may not know whether a machine is being used full time in a particular department. In the mobile factory, management thinking should be oriented along plant instead of departmental lines to avoid buying too many machines for the job. This is precisely what the appliance manufacturer did.



Cross-sections of the Barrymount show details of construction that absorb vibration, shock, and noise, provide for machine leveling and thus improve precision machine performance

Mount Equipment for Mobility

Up to this point, machinery has been considered only from the viewpoint of total plant operations. Much remains to be said about mobility at the work station itself—that is, how to *combat* it.

In operation, machines must be firmly anchored in place to absorb the vibrations and shocks that might otherwise cause them to "walk." They must be level to avoid damaging stress on various structural members, and isolated so no vibrations are transmitted through the floors and walls of the building. Precision machinery, such as grinders, introduce a further problem; these must be isolated from structure-borne vibrations or nearby machines that might cause variations in surface finishes.

On one occasion we sent out a questionnaire to nearly 1000 companies asking if rejects in precision manufacturing operations could be directly traced to vibration. About one-third felt there was, indeed, a definite relationship between rejects and vibration. One company making precision-ground optical lenses reported a rejection rate of nearly 15 per cent, entirely due to building-borne vibration from other machines in the plant.

Paradoxically, the self-levelling machine mount provides a combination of a firm anchorage, shock isolation and noise abatement, while at the same time affording the desired element of mobility.

The points enumerated are a brief check list for attaining the greatest potential from an automated production line. To round out the list, mention should be made of the other factors to be considered by a careful plant engineer:

1. Work simplification—avoiding duplicated motions.
2. Methods analysis—what is the "one best way" to do a job.
3. Work scheduling to avoid material bottlenecks.
4. Reduction of set-up time.
5. Properly designed parts and tools.

Design eliminates need for holes in the floor. Leveling adjustments are made from the top and involve no pry-bars, wedges, or shims

It is reasonable, although perhaps trite, to predict that in the days ahead cost of manufacture will be a more important consideration than ever before. The period of war-time economy when quality and quantity of production far outweighed cost considerations is no longer with us. Suppose you ask yourself, where can costs be best reduced?

Few prognosticators see any decline in direct costs—labor and material—in the foreseeable future. At best, cost of these items is expected to remain the same or advance slightly. The conclusion is obvious: increased production efficiency through mobility offers tremendous possibilities toward lowering cost of production. Certainly, it offers a great impetus to small plant automation and the general concept of the automatic factory.

DR. PAUL H. SAVET, head of the research group at Arma Corp., has been a leader in fluid dynamics and electrical research fields since coming to the United States in 1941. Positions held include research engineer for Fairchild Corp. and Borg-Warner Corp., scientific consultant, chief research engineer, vice president and president of the Newton Co. Before coming to America, Dr. Savet was scientific advisor to the French Air Ministry and an assistant professor at the University of Paris. He has an electrical engineering degree from Ecole Superieure d'Electricite, M.S. in mathematics and Ph.D. from the University of Paris. His many patents and technical papers cover optical, electrical, and mechanical systems; aerodynamic, hydrodynamic, and thermodynamic studies.

COMPUTERS CAN BE SIMPLE

All the talk of giant brains, nervous breakdowns, and human characteristics is countered by development of the thermal computer. Tiny size, fly weight, plug-in replaceability brings the computer closer to general utility which will make it just another wonder of our age

By DR. PAUL H. SAVET
Head, Research Group, Arma Corp.
Garden City, N. Y.

MENTION OF COMPUTERS generally brings to mind complex instruments with Slavic names, maintained by teams of psychologists. This other world remoteness has been created because of what computers cost not because of wonders performed. Size and investment have limited the computer to scientific and experimental fields with only occasional application in business and industry.

Devices have been perfected for gathering and measuring data on most operating details. Electrical transmission of such information, display mechanisms and order devices controlled by electrical signals are highly developed. Servomechanisms have been made smaller and more dependable but are still essentially combinations of amplifiers, motors, generators, and tachometers functioning through electrical cams or induction potentiometers.

Automation of many machines and processes has awaited development of an economical device that could perform selective and mathematical operations on input signals and with the resulting "answers", control order devices and servomechanisms. The veil of semihuman qualities would pass with a substantial decrease in cost.

A promising development in the simplification of computers is the analog computer based on heat transfer. Mechanical movement is eliminated by the process of converting electrical input signals to heat, and through automatic computing derived from built-in circuitry. The transducer uses the heat to change resistance of temperature-sensitive circuit elements and produce electrical order signals dependent on the input signals.

This small computer is capable of doing basic algebraic calculations and generations and solving vector components accurately enough to serve broadly in automation of machines and processes. Immediate utilization in aviation is obvious where advanced means are needed to reduce pilot strain. Other aircraft applications are calculations involved in true speed indicators and angle of attack indicators. Low cost added to small size extends

uses beyond those involved in national survival. Too new to list industrial applications, it remains for manufacturing engineers and computer specialists to collaborate and perfect this link between the sensing instruments and actuating devices.

How the Computer Functions

Heat transfer analog computers utilize heat created by an incoming signal to cause unbalance in a Wheatstone bridge by heating temperature sensitive conductors in the bridge circuit. Output of the transducer is a function of the unbalance and is also proportional to a reference signal supplied to the bridge. Both basic components, transducer and Wheatstone bridge, are of course well known, but combination and application to computers are recent developments.

Heater element circuits basically are as shown in *Fig.* 1. Difference of heat dissipated between the resistors is proportional to the product of the incoming electrical signals a and b, since

$$(a + b)^2 - (a - b)^2 = 4\,ab$$

Phase difference, θ, between a and b would cause the heat differential to be $4\,ab \cos \theta$.

Differential of sensing element resistance, caused by heat transmitted from the heater elements, *Fig.* 2, is a direct though not necessarily linear function of the heat differential. Output d is proportional to reference signal R if the reference signal is moderated to prevent self-heating. The general relationship between the basic transducer variables may be expressed as $d = Rx\ \mathrm{f}\ (ab)$. The function of x has been found through experimentation to be of the form

$$\mathrm{f}\ (x) = \frac{K\,x}{1 + pt}$$

where K is an attenuation factor, t a time constant and p the performance operator. Recording transient response of the transducer under step function exitation inputs established this relationship.

Mathematical Operations

In the transducer shown in *Fig.* 3, two pairs of sensing elements, matched to each other, are used with a single pair of heater elements. By applying the general relationship to each combination of heater element-sensing element pair it is seen that

$$y = \frac{b}{\dfrac{1 + pt}{KGaR} + 1} = \frac{ad}{c}$$

Because of sensing element matching and with high values of G, the open-loop gain of the amplifier, y is matched to b, and $yc = ad$ or $bc = ad$.

Basic limitations of the multiplier are due to the attenuation factor K and the time constant t. In the original model, K had a value of 1/300 for appropriate values of input signals b and c. Lat-

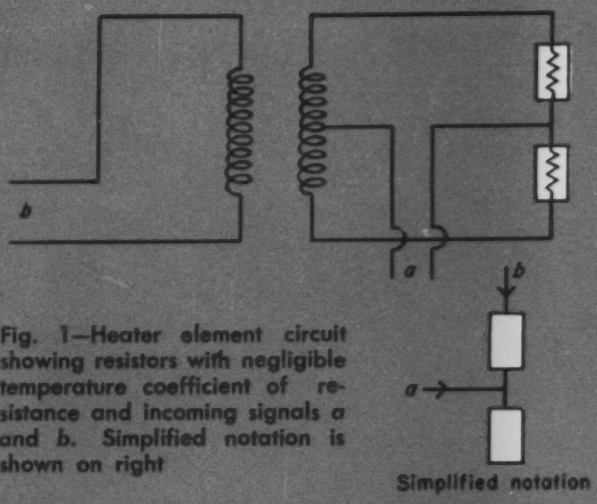


Fig. 1—Heater element circuit showing resistors with negligible temperature coefficient of resistance and incoming signals a and b. Simplified notation is shown on right

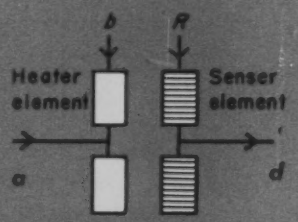


Fig. 2—Simplified transducer with heater element and sensing element. Heater element is in thermal but no electrical contact with sensing element. Heat transfer occurs only between heater-sensing pairs, not between the two sensing elements or between the two heater elements or between cross pairs. Heater element contains resistors with negligible temperature coefficient of resistance; sensing element contains resistors with large temperature coefficient of resistance

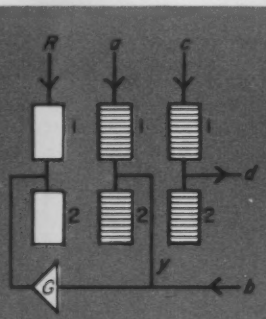


Fig. 3—Transducer application with two pairs of sensing elements used as a multiplier and divider, shown in simplified notation. Sensing elements of (1) are matched to each other as are those of (2)

Nomenclature

G = Amplifier gain.
K = Attenuation factor.
R = Reference signal, volts.
a = Input signal, volts.
b = Input signal, volts.
c = Input signal, volts.
d = Output signal, volts.
p = Performance operator.
t = Time constant, seconds.
x = Heat transfer function.
y = Internal signal, volts.
θ = Phase angle, degrees.

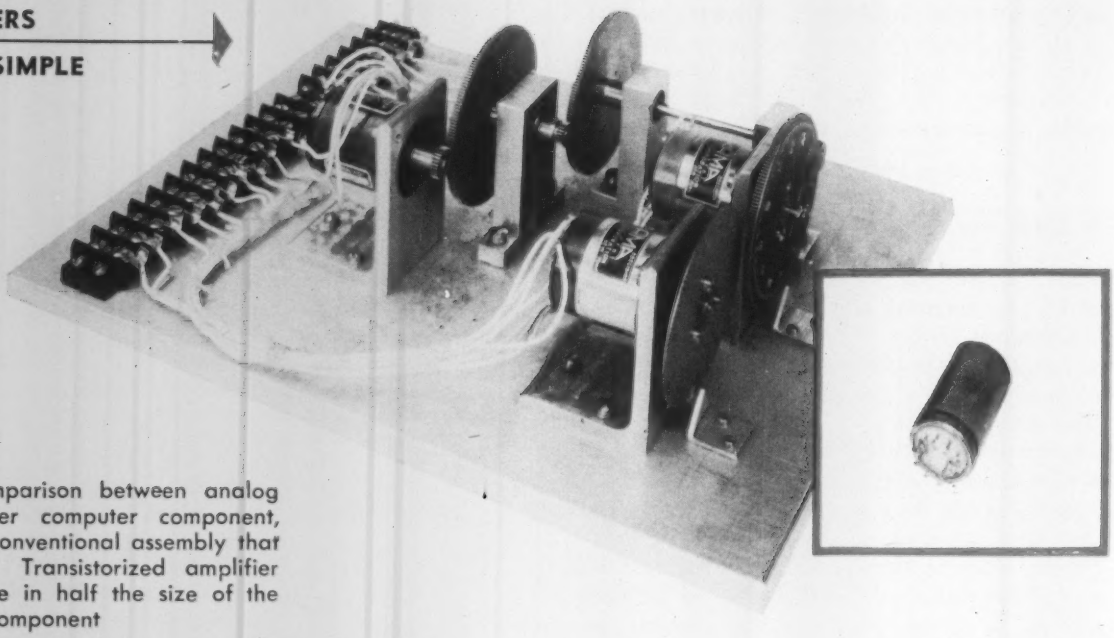


Fig. 4—Comparison between analog heat transfer computer component, right, and conventional assembly that it replaces. Transistorized amplifier will package in half the size of the computing component

est design raised K to about $\frac{1}{2}$. Time constant has been reduced from about 10 seconds to 1 second and in a recent experimental model, amounts to barely a few milliseconds. Exclusive of the amplifier which might be transistorized, the multiplier weighs a few ounces and occupies 5 to 6 cubic inches, *Fig.* 4.

Technique employed for differentiation or integration of dc signals cannot usually be used with ac because, for one reason, any direct integration of differentiation would be applied to the carrier rather than modulation of the carrier input. Use of a thermal transducer overcomes this difficulty since the transfer function is applied to the rms and not instantaneous value of the incoming signal. Circuit requirements in addition to the thermal transducer include a cathode follower and high-gain amplifier.

Further Simplification

Latest development in heat transfer analog computers is the self-heating transducer in which heater elements and sensing elements are identical, *Fig.* 5. Reference signals are 180 degrees out of phase so that while L_1 is heated, L_2 is sampled and vice-versa. Since both elements are tungsten filament light bulbs, high average filament temperatures make possible reduction of the time constant to a few milliseconds and attenuation to about 6 db ($K = \frac{1}{2}$ or slightly less). Operation of this transducer is similar though not identical to the other type discussed and differences are presently under investigation. These units will probably simplify problems already solved by original transducers and in all likelihood will permit economical solution to new problems.

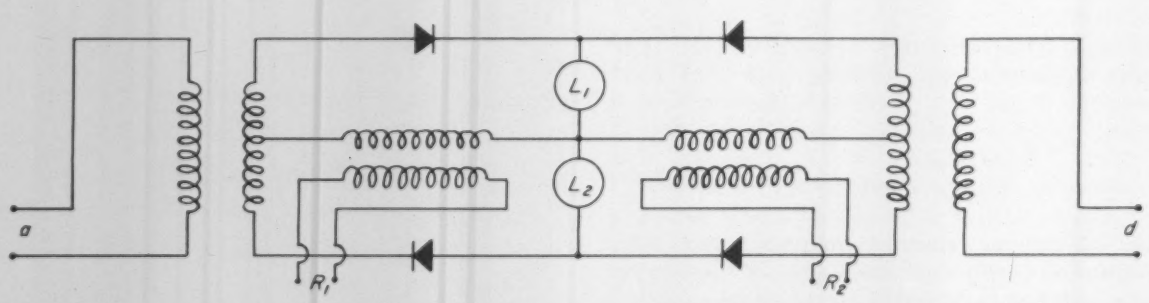


Fig. 5—Self heating transducer with combined heater element, sensing element design. Actually L_1 and L_2 are tungsten filament light bulbs

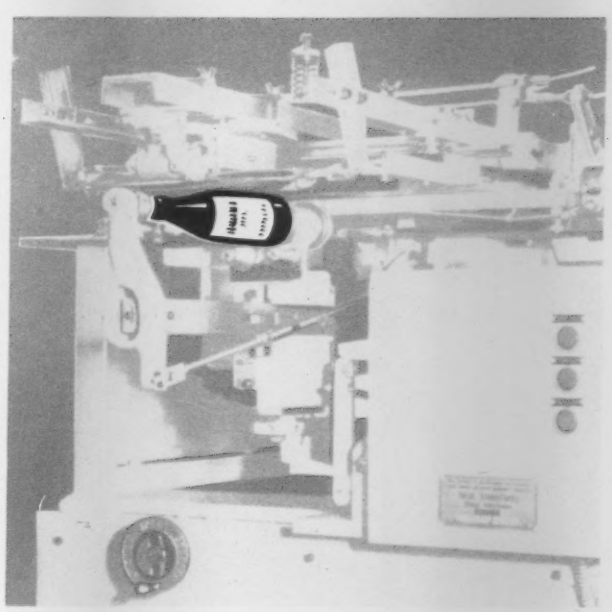


Fig. 1—Solar hand fed semiautomatic glass container decorating machine with a 12 oz bottle in the printing position. A long operator training period is required for this unit.

ATTACHMENT AUTOMATES CONTAINER DECORATING

When the semiautomatic features of a machine are troublesome, first consideration should be conversion of those features to full automatic operation

By **ERNIE HAUK** and **LAWRENCE HAGERMAN**
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HIGH-SPEED, hand-fed, quantity production operations present many problems which can be readily solved with automation. One such area is that of decorating and labeling glass containers and beverage bottles. Machines for applying color labels require highly trained operators to position, rotate and remove bottles, *Fig.* 1. Requiring six to eight months of training at considerable expense, operators are a critical factor in maintaining acceptable rates and costs in production.

With labor more difficult to obtain and retain on such operations, operating costs rising, and increased output efficiency imperative, the need for fully automatic equipment became obvious. Here however, the critical factors of cost and complexity proved to be important considerations in obtaining economically suitable equipment. The most acceptable solution proved to lay in the use of "package" equipment for converting to full automatic operation. This unit, *Fig.* 2, and its operation will be treated briefly in this article.

Paper on which this article is based received honorable mention in the James F. Lincoln Arc Welding Foundation Mechanical Design Award Program, 1953.

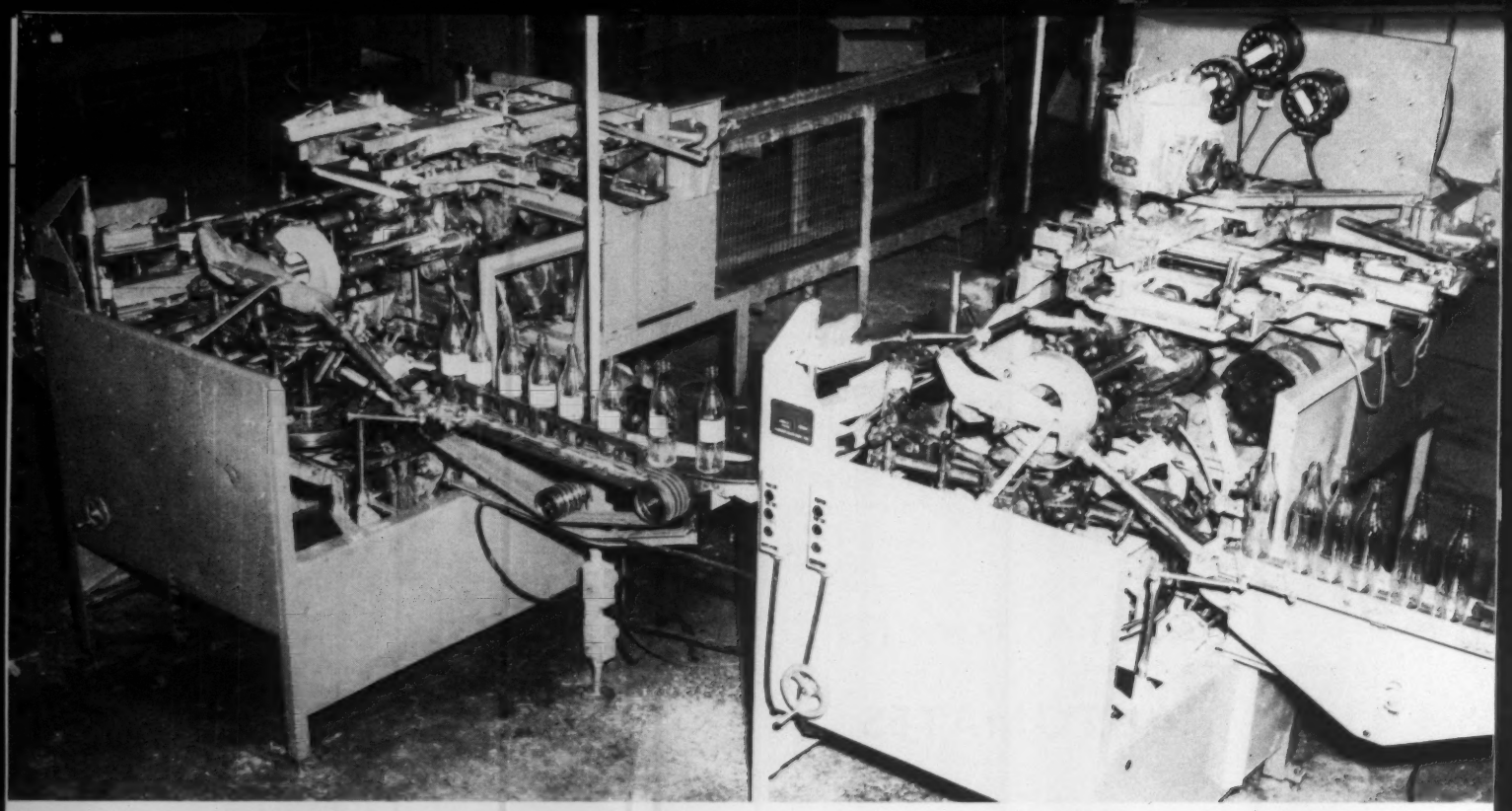

Fig. 2—Two Solar machines converted to fully automatic decorating units by installation of Hagerman attachments. These machines are capable of printing on round glass containers in sizes ranging from 6 to 32 ounces at the rate of 60 bottles per minute. The pair shown are printing in a two-color operation

COLOR DECORATING

▶ Semiautomatic Decorating

In the semiautomatic process, the operator places the base of each bottle in a chuck and aligns the neck with a mouthpiece to position the container for printing by a screen and squeegee. Pattern is furnished by a fine wire mesh which passes color pigment onto the bottle forming the required label or decoration. This screen is held in a horizontal plane and as the bottle is chucked, screen and squeegee move down to make contact with the glass surface so that the bottle can be rolled across the wire mesh. After printing, screen and squeegee return to their "up" position, the bottle is released by the chuck, and the operator removes the container with one hand while reloading the machine with the other for completion of the cycle.

▶ Conversion to Automatic Operation

To insure an automatic attachment capable of converting hand-fed machines into fully automatic units, *Fig.* 2, design to perform the required operation was controlled by several factors. Bottle loading must be scheduled and properly rotated on the machine screens during each printing stroke. Mechanical handling should not smear painted areas on the containers. Size of the completed unit was the determining factor in the method of moving bottles into printing position and ejecting them from the machine.

In operation, containers are fed into the attachment down an in-feed conveyor assembly provided with a simple starwheel escapement mechanism serving to keep the containers uniformly spaced. At the end of the conveyor, containers tip forward and drop into a nest or pick-up station, *Fig.* 3. From this station the containers are transferred to a turret assembly by four loading arms hinged to a table which rotates continuously about its vertical axis. Cushioned carriers of the loading arms pass under the container resting in the pick-up station and carry it approximately 90 degrees to a position for transfer to the turret assembly.

This turret assembly, cam operated, rotates intermittently about its horizontal axis in such a manner that during 30 per cent of each cycle containers are being simultaneously loaded and unloaded. Remainder of the cycle is utilized for simultaneous registering and decorating (printing) in two separate stations of the turret assembly. Rotating speeds of table and turret are synchronized to insure proper alignment as the turret picks up the container with a chucking action. After

the container is chucked by the turret, it is held until the turret indexes four times or 360 degrees. In *Fig.* 4, the container is shown chucked and indexed to the registering position. At this point a second cam, also mounted at the rear of the main drive installation, pulls the turret back endwise about 3/16-inch, serving to accomplish the following:

1. Clutch the container chuck mounted in the turret to the registering unit which rotates the container at about 90 rpm for register.
2. Clutch the container chuck in the top or printing station to the printing spindle which rotates the container during printing.
3. Release the brake assemblies mounted at each of the four turret stations. These brakes prevent the container from rotating out of proper register as the turret indexes carrying the container from the registering position to the printing position.

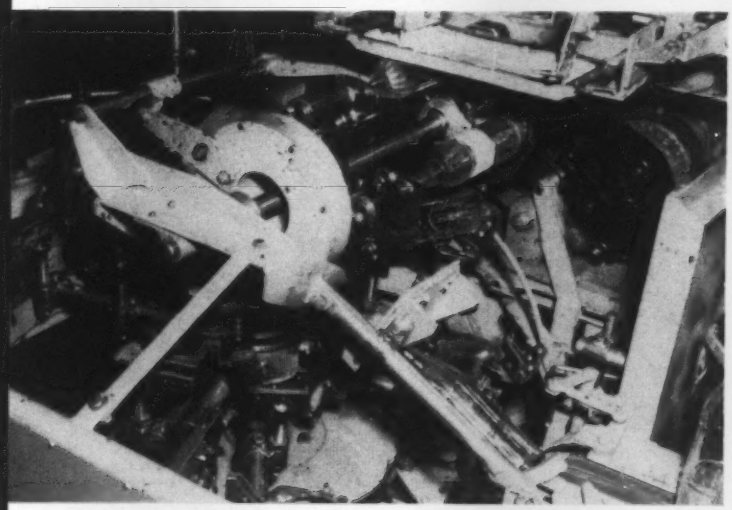

Fig. 3—A container resting in a loading arm is shown moving into position to be chucked and picked up by the turret which is rotated intermittently in 90 degree increments by a cam in such a manner that the turret begins to index just as a loading arm passes a container under the turret

Fig. 4—Chucked and indexed in the registering position, a molded glass nub and finger stop axially positions the bottle for printing

The register unit consists of a friction drive which rotates the bottle until stopped by striking a positive finger-stop projecting into the path of a small nub molded on the bottle surface just above the base. Accuracy of register is maintained by a friction drive which holds the container firmly against the finger-stop until the turret drops back 3/16-inch.

After register the turret is ready to index the container to the printing position. Again pulled back and clutching the printing spindle, it places a properly rotated bottle in position for decorating screens and squeegees to perform the printing operation.

Printing stroke completed, the turret again indexes the bottle 90 degrees to a dead position. During the next (fourth) indexing cycle, the container is released from the turret into one of four take-out arm nests mounted on the rotary table and following the loading arms by about 15 degrees. Loading and unloading of the turret is accomplished as the turret indexes—loading occurs just after the turret starts to rotate and unloading just as the turret ceases to rotate. The take-out arm carries the bottle from under the turret to an upright position, where it is caught and scooped off onto a conveyor belt or take-away table.

Automation Not Only for Giants

It is interesting to note that all components of the attachment are of standard stock machined on tools found in any small shop. Fabrication by arc welding was the designer's choice in order to keep manufacture completely within these capabilities. It should be encouraging for small firms to see that a piece of complicated automatic machinery can be designed, built, and produced with relatively meager facilities by utilizing the arc welding and standard stock combination.

ELECTRICAL MAINTENANCE IN AUTOMATION

By R. N. JOHNSON
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MANUALLY POWERED MACHINES have developed through mechanically powered and manually operated, to operator controlled and automatically operated types on which the operator loads and unloads the machine and starts the operating cycle. The present trend is toward completely automatic operation of machinery including loading and unloading.

This is not such a big step from what is being done today, but in the design stages for completely automatic production, several problems present themselves aside from operation of the machines. Looming large among these is maintenance.

When we had manually powered machines, maintenance problems were entirely mechanical. When powered machinery came into use, maintenance personnel had to become familiar with the upkeep and installation of motors and their associated controls. These were relatively simple and their maintenance was accomplished without too much difficulty. Machines then began to use hydraulic and air power. Limit switches, timers, relays and other less simple electrical control equipment had to be used, complicating the maintenance problem. This condition, as it stands today, places maintenance personnel in a dominant position in the production plant. Yet, emphasis in engineering and development of machinery has been predominantly on ease of operation and volume of production, with maintenance secondary.

If the production plant of tomorrow is to be a completely automatic plant, development of machinery that goes into that plant of necessity will be designed with maintenance as a predominant factor. If not, unskilled or semiskilled personnel freed by the automation equipment will have to be replaced by an equal number of highly trained service technicians. To reduce the technical knowledge necessary for service personnel, conventional magnetically operated components should continue to be used whenever feasible.

To make their design engineers conscious of the need for consideration of maintenance W. F. & John Barnes Co. uses a training program that includes servicing of machines in the customers' plants and construction of machines on the Barnes assembly floor. This presents an opportunity to observe problems of maintenance that can be created by design neglects. Good maintenance begins "on the board."

As machines become more complicated from a control point of view, more information about machine control must be available to the plant maintenance personnel. This information must be on paper, not verbal. It must be in the hands of maintenance personnel, not in a file in the office.

Complicated multiline graphs presented in highly technical form, or long verbal descriptions using highly technical language tend to tire the man who is trying to assimilate the information, and frequently cause him to refuse to read all the information supplied. An antagonistic attitude toward the machine due to lack of understanding, and poor maintenance are the results. Barnes recommends to customers that they encourage maintenance and operating personnel to steal control drawings from their machines. It is a healthy sign of interest in machine operation.

Some methods that are being used to familiarize plant maintenance personnel with operating principles of our machines are:

1. Personal interviews between our engineers and customer production and maintenance engineers before and during design of the machine and after installation of the machine.
2. Introduction of mechanical trouble finders on machinery to help maintenance personnel locate trouble with a minimum of down time.
3. Use of customers' maintenance personnel in installation of machines.
4. Presentation of complete information on the controls of the machine.

This information consists of:

1. Schematic line drawing.
2. Machine equipment layout.
3. Complete equipment parts list and recommended maintenance stock parts list.
4. Step-by-step description both in simple graphic form and in writing of the mechanical sequence of operations of the machine.
5. Step-by-step description in written form of the electrical sequence of machine operation.
6. Inclusion of all this information into a standard binding.

Success of the completely automatic production plant will depend largely on the attitude of the manufacturer of automatic machines toward maintenance problems associated with those machines, and, conversely, on the attitude of customers' maintenance personnel toward machines which are produced with maintenance in mind.

Article based on a paper presented at the 18th Annual Westinghouse Machine Tool Electrification Forum, Buffalo, N. Y., April 1954.

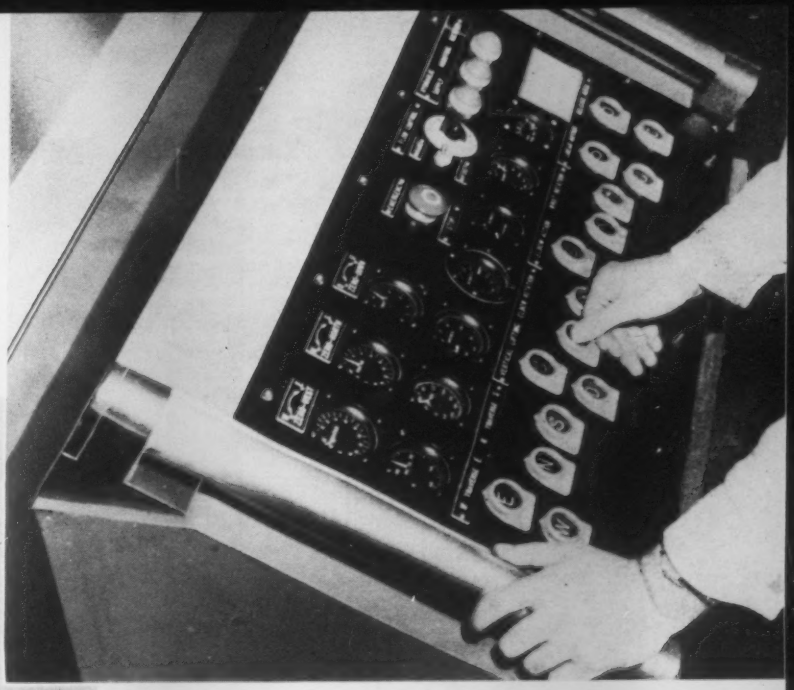
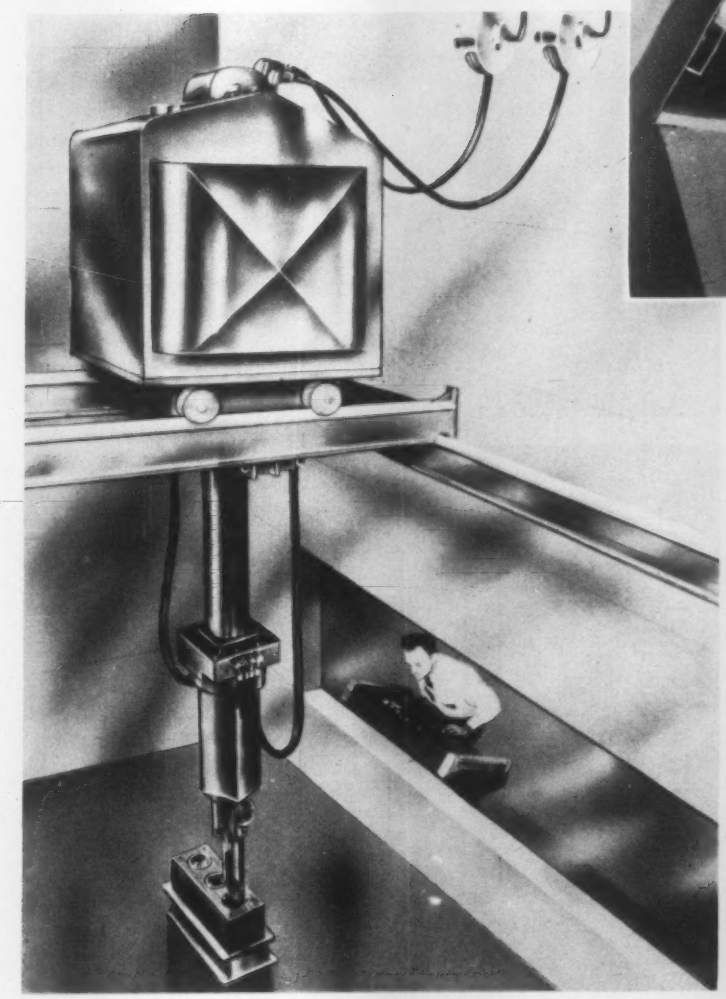


Fig. 1—Manipulator in the process of engaging various tools in an atomic cell. Control panel follows manipulator traverse and a bromide window protects the operator



REMOTE HANDLING WITH HYDRAULICS

By **JULIUS KENDALL and BEAL P. MOORE**
Vice President and Chief Project Engineer
Greer Hydraulics, Inc., Brooklyn, N. Y.

Processing of deadly substances is becoming an increasingly more common problem. Advent of nuclear power brought it into sharp focus and today automation of these operations has been highly successful. Hydraulics offers an efficient fail-safe means

HANDLING of radioactive and toxic materials in the atomic and chemical fields has made automation mandatory. In many instances remotely controlled automatic manipulation machinery provides the only means of safe operation. Typical of such equipment is the manipulator shown in *Fig.* 1 developed and built by Greer Hydraulics to operate in areas of high radioactivity. It is designed so as to resist corrosive washdown solutions, operate safely in explosive atmospheres and be capable of complete drainage.

Providing maximum dexterity within necessary strength-lift specifications, the manipulator will perform a complete range of motions—longitudinal,

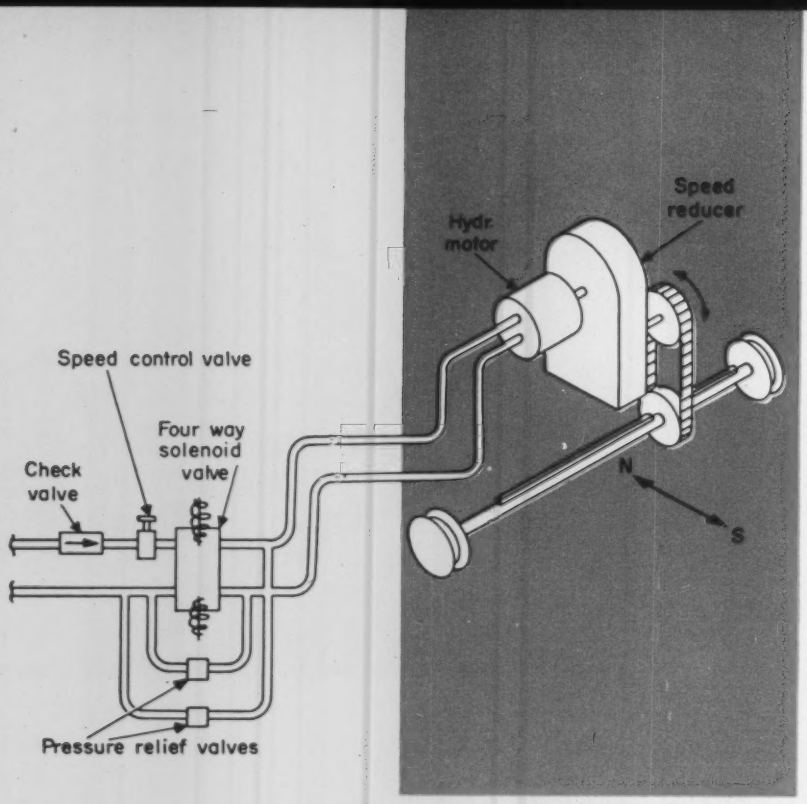
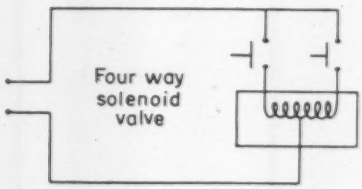


Fig. 2—Control and drive for longitudinal motion. Bridge wheels are driven by a 1½ hp hydraulic motor from a feathered key shaft to permit transverse motion



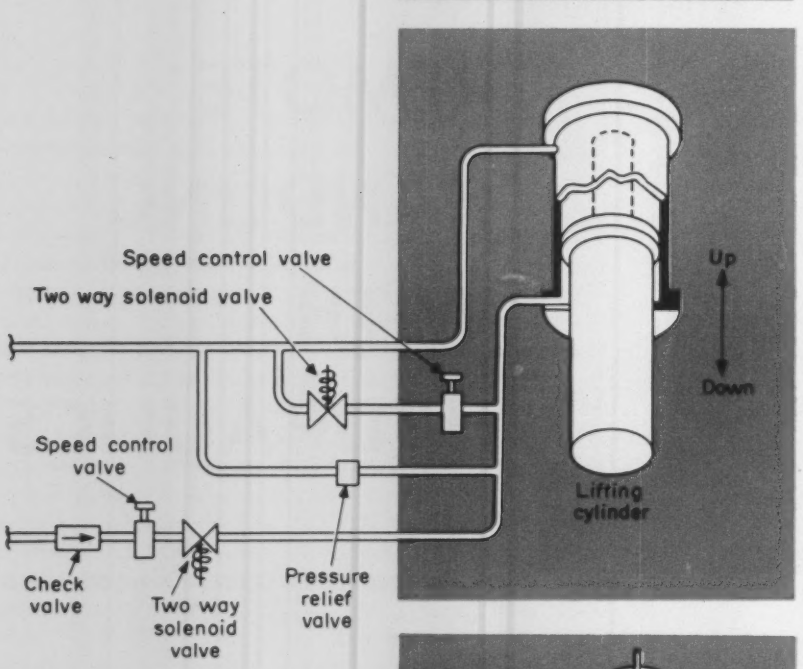
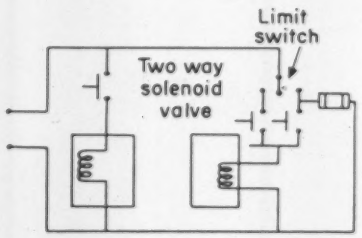


Fig. 3—Control and drive for vertical motion. A maximum 1000 pound load can be lifted from hooks at the elbow. Piston is lowered by gravity



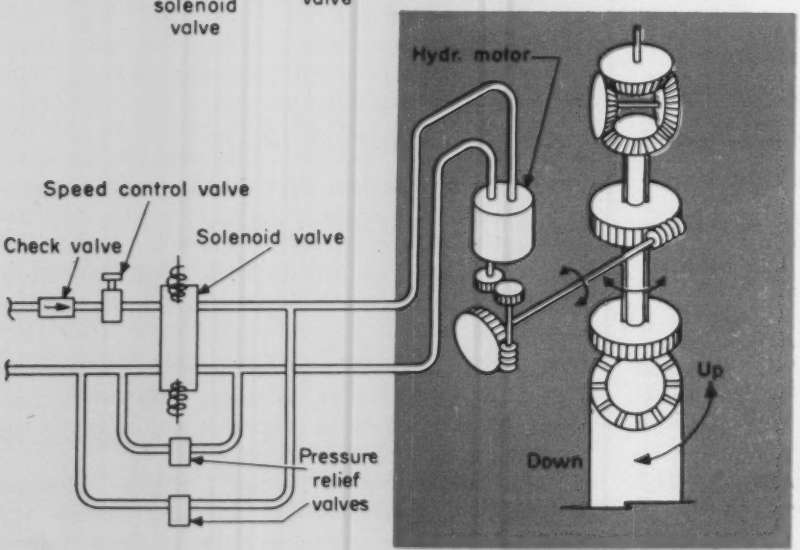
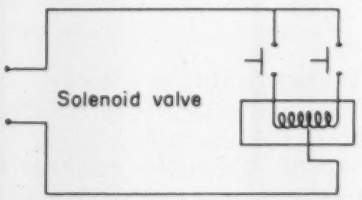


Fig. 4—Control and drive for elbow actuation. Maximum torque is 2100 in-lb, hydraulic motor operating pressure 250 psi, fluid flow 2½ gpm



traverse, vertical, elbow rotation, and hand or tool actuation. Each motion is independent of any other, making possible individual performance or simultaneous combination.

Elements of Movement

Longitudinal and transverse motions are accomplished by a bridge which is mounted on V-groove wheels running on round rails the 18-foot length of the cell, and a trolley which moves across the cell for 8½ feet on similar V-groove wheels. Electric control and power supply connections come into the trolley through retractable electric cables. A 7½ hp, 220-volt electric motor drives the pump for the hydraulic motors and speed reducers which power bridge and trolley movement. Bridge wheels are turned by a shaft which may be driven from any position of the trolley containing the entire power pack. Hydraulic and gear systems for longitudinal motion are shown in *Fig.* 2.

A stainless steel housing completely seals the trolley from dust and washdown solutions. Due to radiation level in the cell, heat is dissipated by finned tubing external to the power unit housing. A third set of wheels keeps the trolley from tipping and deflecting when a 100-pound side load is imposed on the manipulator. Rails and bridge of this assembly are designed to deflect no more than 1/32-inch when a vertical load of 1000 pounds is applied. Maximum rates of both longitudinal and transverse motions are 10 fpm with variable speed control. The unloader valves on these motions relieve at 125-pound side load in order to prevent damage to the manipulator and cell equipment.

Lifting is done by a hydraulic ram located in the trolley; lift motion is 6 feet maximum. Fingers can take a side load of 100 pounds and vertically lift a 250-pound load. When hooks are attached to the elbow of the forearm, the ram is capable of lifting 1000 pounds. Maximum rate of this motion is 10 fpm lifting and 5 fpm lowering. Height limit control can be preset to prevent the operator from raising a radioactive source above the height of a barrier or access holes to the cell. The hydraulic lifting system shown in *Fig.* 3 consists of a single-acting piston with protective check valves, flow rate controls and unloader valves.

Versatility in rotation is assured by combination of three independent movements of elements below the trolleys—the upper arm, elbow, forearm and wrist. The upper arm is capable of 360-degree continuous rotation as is the wrist. The forearm can be rotated through a vertical arc of 135 degrees at the elbow. Upper arm rotation is provided by a gear system including a double worm gear drive powered by a ¼-hp hydraulic motor. A maximum torque of 2100 in.-lb is produced and a maximum speed of 1 rpm possible.

Bending of the elbow at a maximum speed of 1 rpm is powered by a ¼-hp hydraulic motor located in the upper arm. Elbow action is interlocked with wrist rotation through a double differential so as to prevent any interaction between the wrist and elbow movement, *Fig.* 4. Maximum torque is 2100 in.-lb with a 100 pound maximum radial load at the fingers. A ¼-hp hydraulic motor located in the upper forearm powers wrist rotation. A gear system with a double worm gear drive and double differential is used. Schematic of hydraulic and gear systems is shown in *Fig.* 5. Maximum torque is 500 in.-lb, maximum speed 15 rpm.

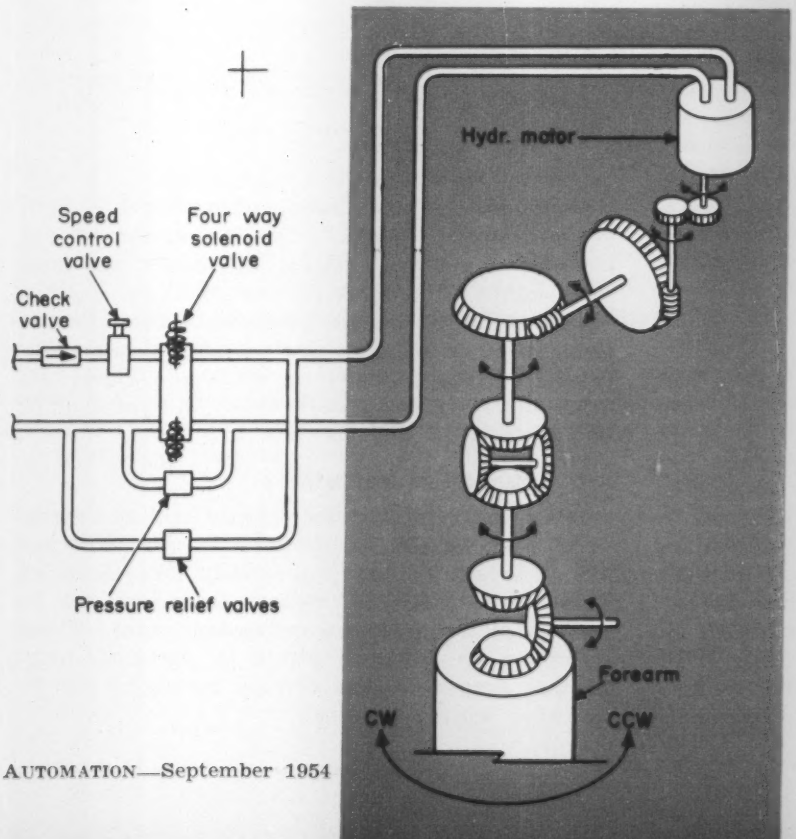
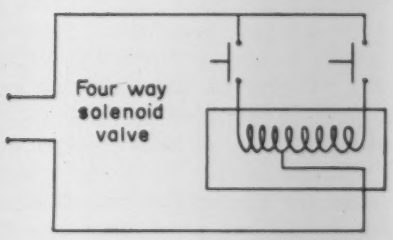


Fig. 5—Control and drive for wrist rotation. Interlocking double differential prevents interaction with elbow movement. Maximum fluid flow is 2½ gpm, pressure 500 psi



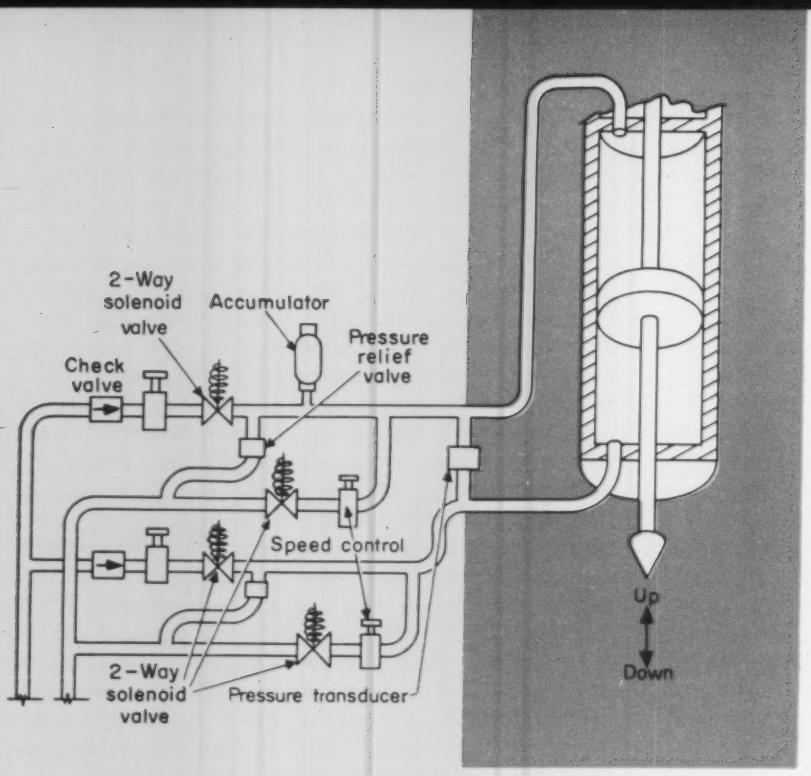
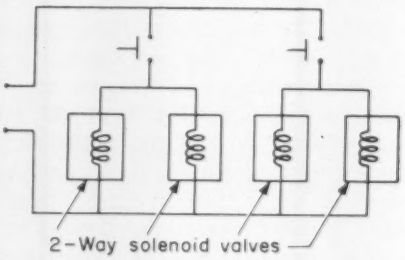


Fig. 6—Control and drive for tool action. Paired solenoid valves reverse system pressure to the double acting cylinder providing positive drive in both directions



Mechanical Hand and Tools

A double-acting hydraulic piston shown in *Fig.* 6 mounted internally within the wrist operates hand, vise, or socket tools at a closing rate of two seconds. Tools are attached by means of four tangs mounted at the end of the wrist and can be engaged and disengaged remotely. The hand tool has a 4½-inch grip and can hold up to 250 pounds, as can the bar vise which has 1-inch hex bar capacity. Third wrist attachment is a socket tool. These attachments and the movements possible allow the manipulator to perform a variety of machining and assembly operations.

Grip circuit of the tool element contains four two-way valves protected by means of check valves, maximum flow rate valves and unloader valves. A small accumulator which supplies pressurized fluid to compensate for oil leakage or movement of the object held prevents slippage of the grips. A differential pressure-senser placed across the double-acting piston lines transmits readings electrically to the control panel.

Hydraulic System and Controls

Heart of the hydraulic system shown schematically in *Fig.* 7 is an 11 gpm pump with maximum pressure rating of 1000 psi. Internal filters of the 20-gallon reservoir can be by-passed in the event that hydraulic fluid forms solids or gelatin from radiation exposure. Oil for the system is selected dependent upon the type of radiation in order to prevent formation of gelatin. Maximum oil flow of 10 gpm is varied by a flow control and relief valve set at 550 psi remotely actuated by an electric servo from the control panel. Each motion has a maximum rate flow control valve that limits speed and all motions are directed by means of four-way and two-way shutoff solenoid valves.

After being pressurized by the hydraulic pump, oil passes through the main flow control valve, check valve, to the accumulator which prevents shock when control valves are actuated. The basic system for all rotary motions consists of the following components:

1. Check valve to isolate motion from the rest of the system.
2. Maximum flow rate control valve.
3. Four-way solenoid valve to select direction of motion.
4. Hydraulic motor driven speed reducer for rotary motion.
5. Two unloader valves for the unloading system set at 125 per cent of the rated load pressure to prevent damage to the equipment.

Control center for the manipulator is a rail-mounted panel, *Fig.* 1, capable of moving the length of manipulator travel. The panel consists of pushbutton controls, remote indicators and indicator lights. Speed control can be adjusted either by a hand knob on the panel or a foot throttle under the panel. An electric pressure gage indicates the grip pressure at the tool. Ultraviolet lights and luminous indicators on the panel allow better visibility into the cell.

Application Versatility

For specific applications, longitudinal and transverse motions can be extended to approximately 200 feet and 40 feet respectively. Where direct vision is not possible, remote indicators can be used for motion guidance and measurement. These indicators are accurate within ¼ per cent; longitudinal, transverse and vertical movement can be indicated within 1/32-inch.

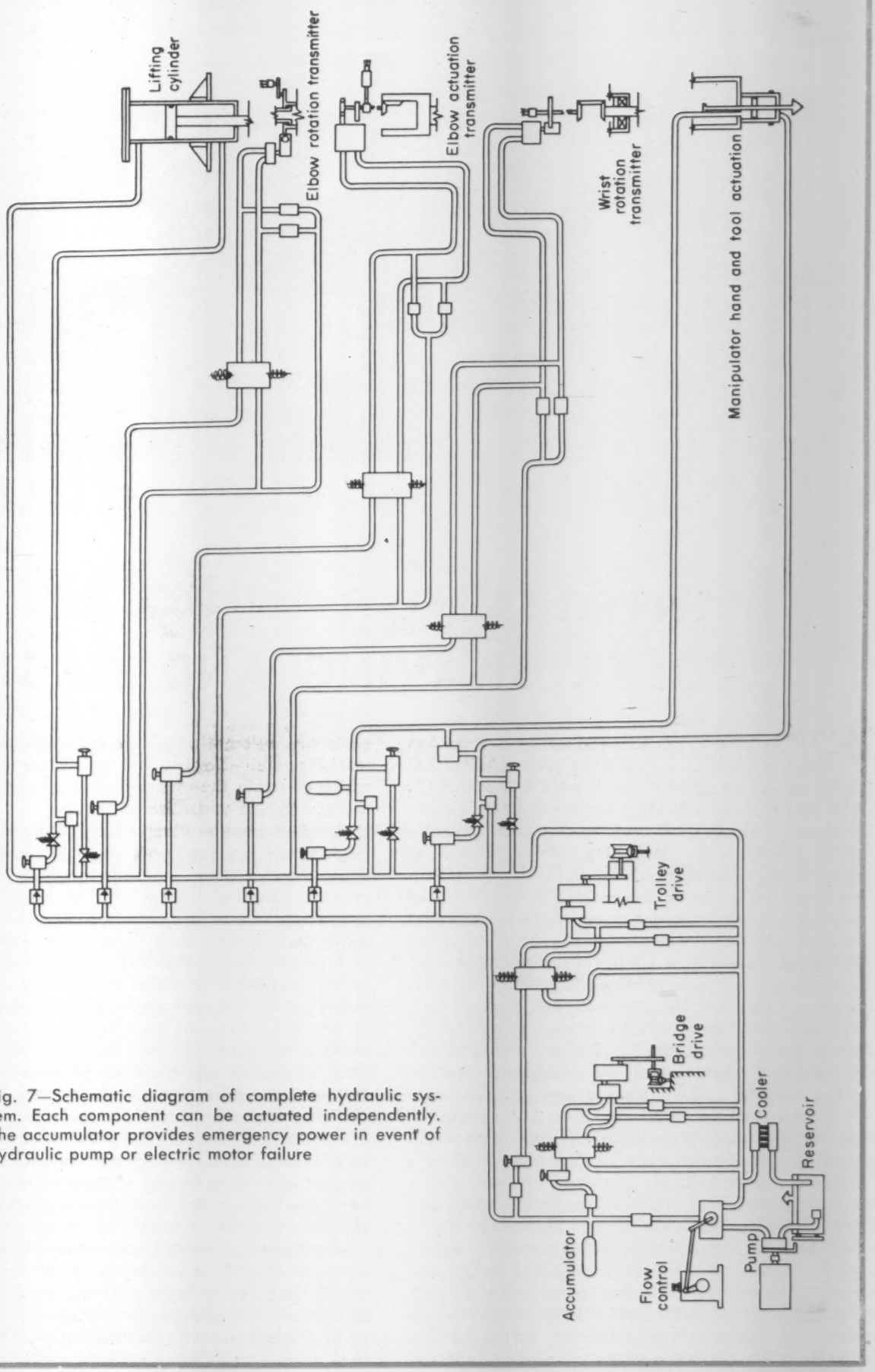
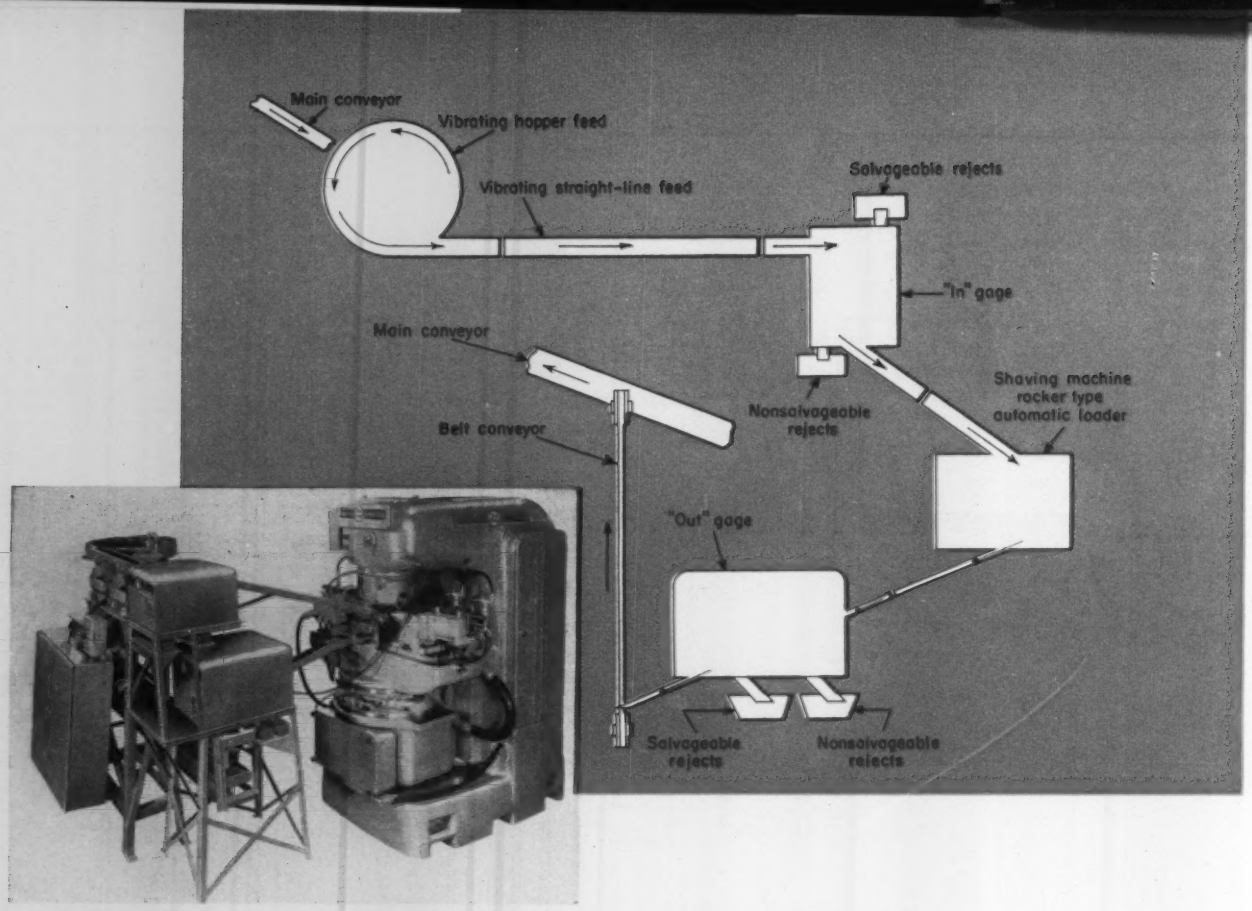


Fig. 7—Schematic diagram of complete hydraulic system. Each component can be actuated independently. The accumulator provides emergency power in event of hydraulic pump or electric motor failure



INTEGRATED GEAR SHAVING AND GAGING

AN AUTOMATED gear production concept has been applied to a Red Ring gear shaving machine developed by National Broach & Machine Co. The unit includes vibrating hopper and straightline feeder, automatic "in" and "out" gages, an automatic loader, a standard diagonal-type Red Ring rotary gear shaving machine, and a discharge belt conveyor unit. Fully automatic gages shut down the machine if too many reject parts are received or produced. Signal lights tell the setup man what is wrong, reducing downtime to a minimum.

Gears are fed to a vibrating hopper by the main conveyor line and the gear shaving, gaging, sorting, and dicharge operations proceed automatically. An in gage checks gears for size before feeding into the shaving machine through a magazine-type automatic loader. Finish-shaved gears are unloaded from the machine to an out gage that checks the parts for size and helix angle accuracy. Gears that pass this final inspection test are deposited on a small conveyor belt to the main conveyor line.

The problem of automatic gaging—sometimes the stumbling block of a modern automation line—is solved in a new and unusual manner. Before gears enter the automatic loader, they pass through a specially designed motorized gear gaging and sorting machine that checks them for size, avoiding machine breakdowns or cutter failures resulting from oversize parts. Over and undersize parts are automatically rejected by the in gaging machine and directed to individual containers which separate the oversized salvageable from the nonsalvageable undersize parts.

Finished gears are inspected in a motorized gear gaging and sorting machine of another design which checks them for helix angle and size accuracy. Like the in gage, this out gage sorts salvageable gears from the nonsalvageable undersize gears and deposits them in separate containers.

A new feature permits the machine setup to be corrected quickly should it start to pass too many reject parts. As soon as a predetermined number of rejects of any one type are produced, the machine is automatically shut down by the out gage. Pilot lights indicate the type of errors.

Gears with rough-cut teeth are loaded in the vibrating type hopper feed unit, from which they are conveyed by a straight-line vibrating feeder unit. Operation of the hopper feed unit is intermittent and controlled by a mechanical feeler unit near the end of the straight-line feeder. Pieces that pass the size inspection check are directed to a feeder chute that leads to the automatic loader. An air-powered rocker-type loader positions the gears, one-at-time, in cutting position beneath the shaving cutter in diagonal shaving machine. An unloading finger picks up the finished gear and places it in a discharge chute to the out gage.

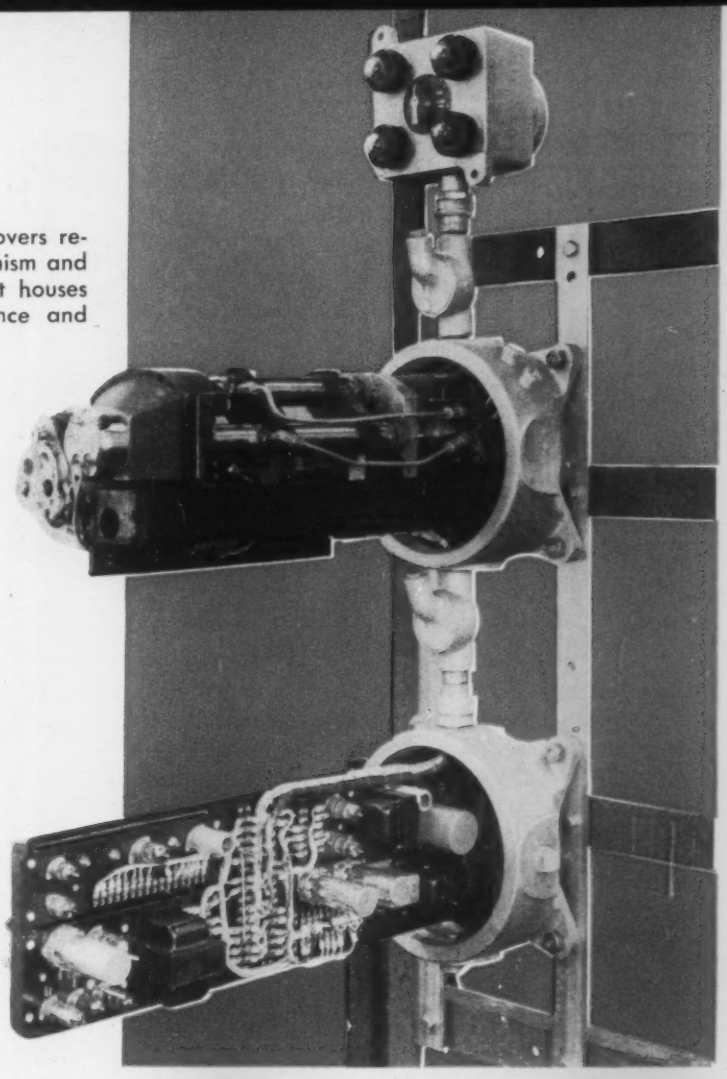


Fig. 1—Tri-Non Analyzer with covers removed from the detector mechanism and electronic components. Top unit houses test circuits used for maintenance and repair of the electrical circuits

CONTROL PERMITS CONTINUOUS PROCESSING BY INFRARED RADIATION ANALYSIS

Infrared spectra of most chemical materials are unique characterizations or "fingerprints" of these substances. Qualitative analysis is only part of what can be determined from infrared radiation. Measurement of radiation-absorption also indicates concentration

SAMPLING AND ANALYSIS of a process stream in industrial installations requires versatile instrumentation so that broad application will prevent prohibitive cost. The advanced state of automation existing in process industries has emphasized need for accurate and reliable instruments, especially since the process plant generally is a high-capacity, high-cost facility and undetected variables can result in serious losses. In some instances laboratory techniques can be incorporated into instrument design so as to serve plant needs. By clear understanding of alternate applications, these instruments can be applied to a range of problems rather than to a single specific measurement.

Selectively and continuously measuring and recording concentration of one component of multicomponent gaseous streams illustrates an area of problems solved by an unusual instrument. One standard method used for continuous gas analysis is the infrared absorption technique. Absorbed radiation by gases at characteristic wavelengths can be utilized to unbalance or actuate electrical circuits and result in a signal that varies with gas concentration. This principle is employed in an instrument known as the Tri-Non Analyzer, *Fig.* 1, a triple beam, infrared, radiation-absorption device designed by the Perkin-Elmer Corp. Design provides for use in measuring single component concentration of many multicomponent streams.

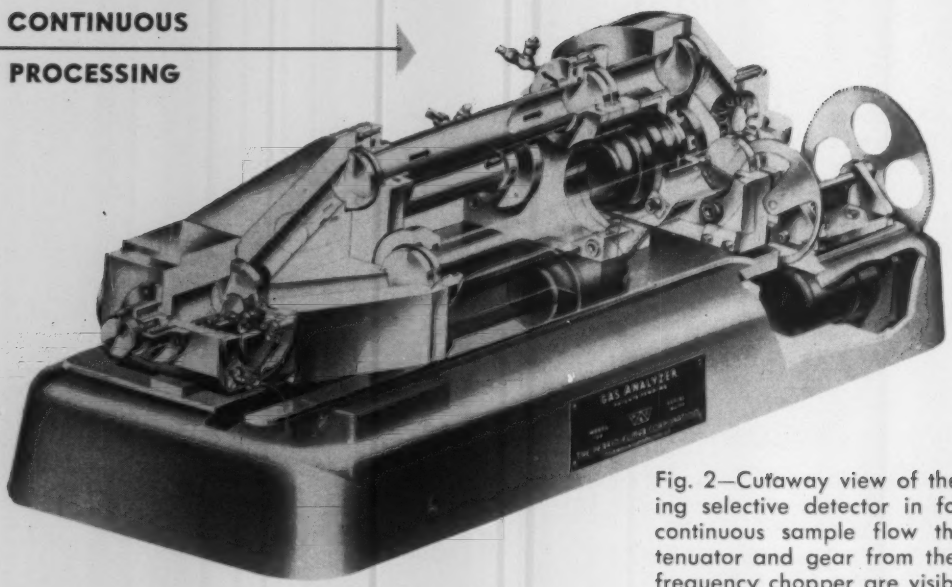


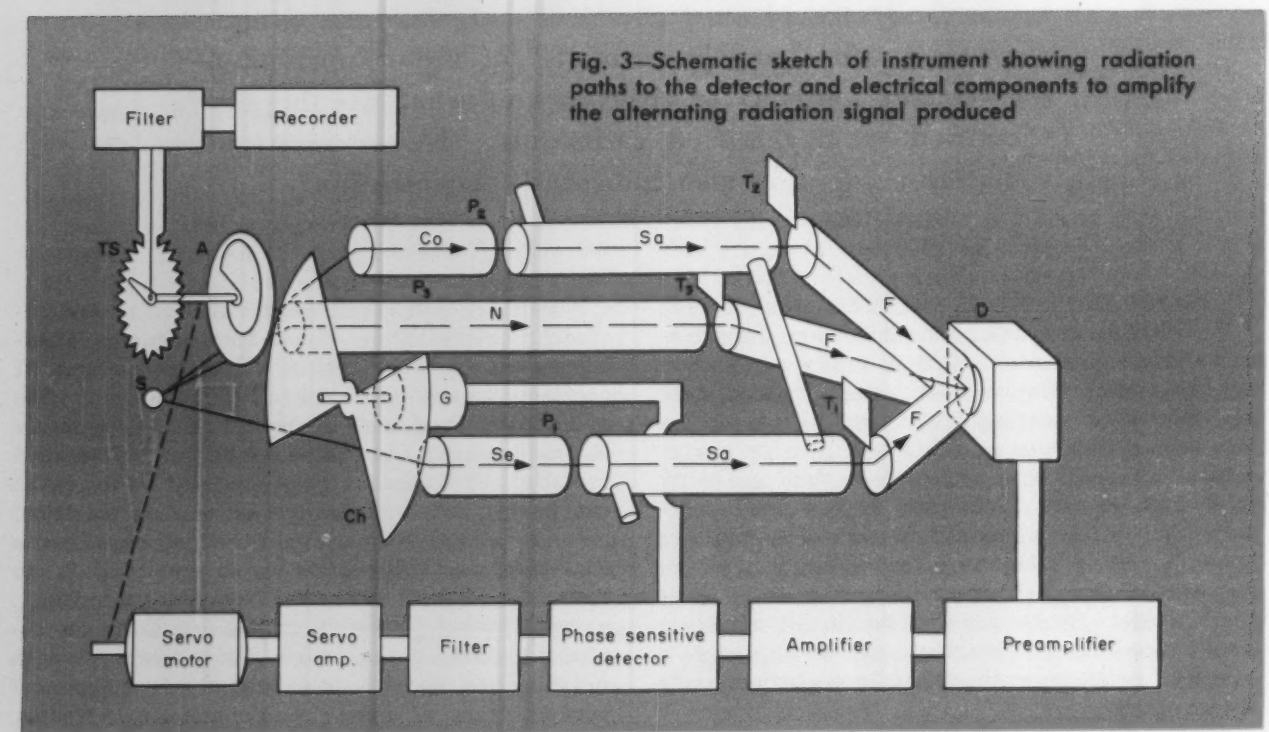
Fig. 2—Cutaway view of the detector mechanism showing selective detector in foreground. Arrows indicate continuous sample flow through the instrument. Attenuator and gear from the servomotor, and radiation frequency chopper are visible toward rear

Elements of the instrument are the detector mechanism, test circuits for maintenance and repair, and the electronic components. Amount of absorption from the sample, continuously tapped from the process stream, is measured in the detector mechanism. Circuit tester permits rapid diagnosis of faulty components as well as instantaneous warning should the instrument go off scale through failure or because of rapid stream change. Included in the various electronic components required are a power supply, gain, and servoamplifiers.

Radiation Analysis

Instruments may be modified to suit particular applications but generally are as shown in *Fig.* 2 cutaway, and schematic in *Fig.* 3. Infrared radiation from a source S is transmitted by internal reflection through three paths, P_1, P_2 and P_3 to a single selective detector D filled with a gas, usually the component to be analyzed. Gas absorbs radiation at characteristic wavelengths, is heated, and causes deflection of a flexible diaphragm, one side of a condenser. Resultant electrical signal from a

Fig. 3—Schematic sketch of instrument showing radiation paths to the detector and electrical components to amplify the alternating radiation signal produced



change in condenser capacity with deflection is a measure of radiation incident on the detector and varies with concentration of the component in sample cell *Sa*. Components in the paths vary with the problem, but in general are as shown: P_1—sample *Sa*, sensitizing *Se*, and filter *F* cells; P_2—sample *Sa* compensating *Co* and filter *F* cells; P_3—attenuator *A* and filter *F* cell. The chopper *Ch* varies the radiation beams such that *D* sees radiation successively from P_1, P_3 and P_2.

Instrument operation based on the infrared radiation-absorption technique can be illustrated by a theoretical sample consisting of components, *W, X, Y, Z*, to be analyzed for *X*. *Se* and *D* are filled with *X*. Trimmer T_3 can be adjusted in path P_3 so that the sum of radiant power in P_1 and P_3 equals that in P_2. As the radiation is chopped there is equivalent heating on each cycle and no consequent motion of the condenser diaphragm, thus providing a true zero signal. If the sample flows through sample cells, presence of *X* in the sample will produce a greater cooling effect on P_2 radiation than on P_1 since radiation at characteristic absorption wavelengths of *X* has been eliminated by the presence of *X* in *Se*. Resulting alternation in heating produces an ac signal at the detector which is used to move the attenuator in P_3 until a null signal again results. Motion of the attenuator is recorded on a potentiometer whose deflection can be related to the concentration of *X* in the sample. Other components, *W, Y, Z* have no effect on the instrument if these components have no absorption wavelengths in common with *X*. If they do so interfere, cells *F* and *Co* can be filled with partial pressures of the interferent components making the instrument insensitive to variation in *W, Y,* and *Z*. In compensated condition, the instrument is effectively sensitive only to variation in *X*.

Electrical Amplification Circuit

Alternating radiation signal existing at the output of the detector is amplified electrically to operate a servomotor which rotates the beam attenuator. Capacitance change of the condenser in the radiation detector is converted to a voltage change by a tuned-plate, tuned-grid oscillator preamplifier, then amplified by a 13 cycle per second (chopping frequency) amplifier. This signal is demodulated by a ring diode phase-sensitive rectifier. Polarized dc output is filtered and fed into a 60 cycle per second modulator-amplifier and placed across the control winding of a two-phase servomotor. Circuit diagram is shown in *Fig.* 4.

Since plant hazard frequently does not permit routine checking or trouble shooting in electrical components without shutdown, an external multiposition switch with four indicator lights, shown in *Fig.* 1, permits individual testing of line voltage, instrument power supply, radiation source current, servoamplifier, 13 cycle per second amplifier, and the oscillator preamplifier.

Use of a high-gain radiation null system makes the instrument virtually insensitive to detector and electronic gain variations. Method of achieving radiation null balance with a third channel does not upset compensation required to eliminate signals from background components, regardless of automatic attenuator position. The recorder may be located adjacent to the instrument or in a distant central control room.

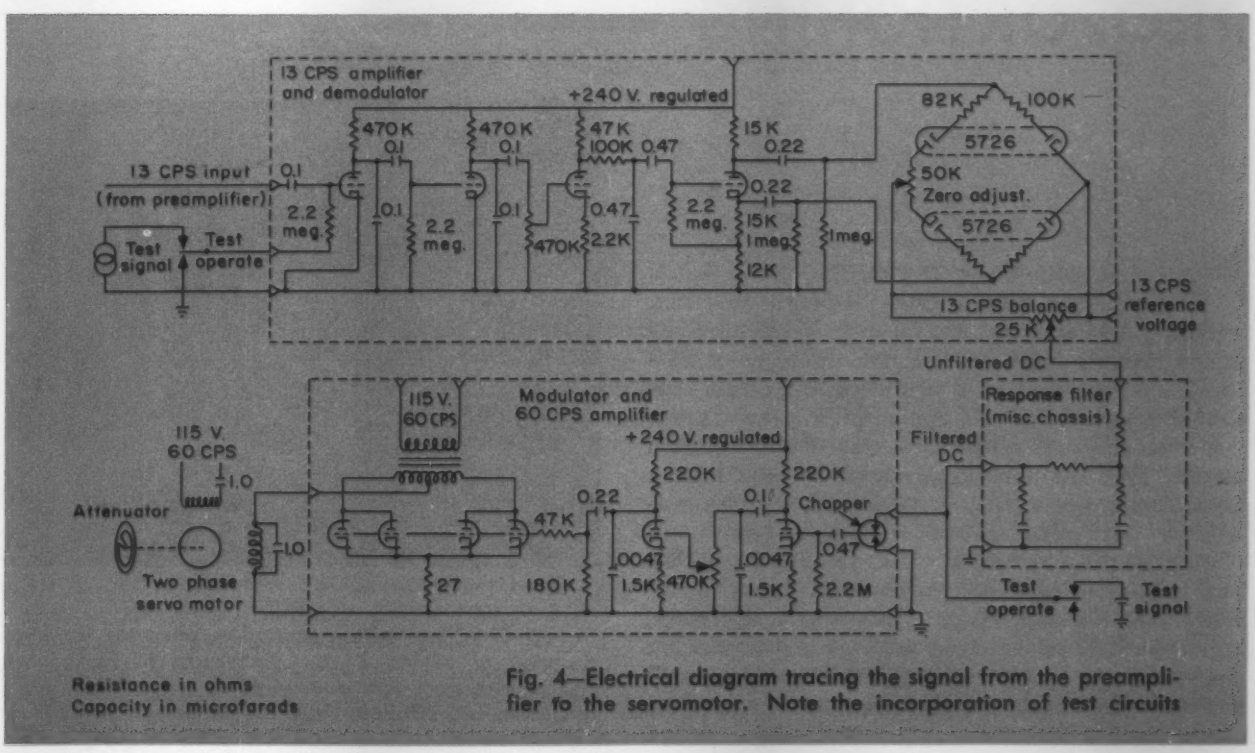


Fig. 4—Electrical diagram tracing the signal from the preamplifier to the servomotor. Note the incorporation of test circuits

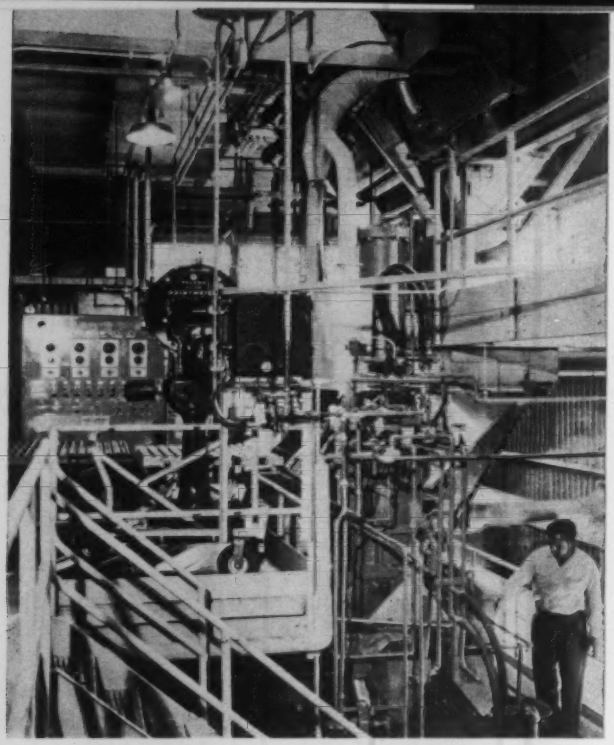


Fig. 1—Inside mixing room, plant manager checks Banbury Mixer. For the sake of cleanliness, all equipment is enclosed, pigment bins are capped and top doors on the carbon-black bins are sealed

RUBBER COMPOUNDING IMPROVED WITH WEIGHT-CONTROLLED

BATCH PROCESS PROPORTIONING

AUTOMATIC PROPORTIONING in a batch process can reduce costs through precision weighing and absolute control over weighing operations. Harris Products Co., manufacturer of rubber goods, installed such a system and found considerable savings in addition to an improved product over the finished slab furnished by a custom mixer. The system, engineered by Richardson Scale Co., reduced labor costs, increased batch production rate, and improved quality control.

Built as an addition to the processing plant, the new mixing room, *Fig.* 1, houses a Banbury mixer, scoop bins for storing pigments and accelerators, equipment for an oil injection system, equipment for conveying and weighing slab stock, and the storage bins, conveyors, and scale involved in the proportioning process.

Slab stock is dropped into the Banbury manually, the carbon blacks, automatically. Weights of different blacks desired for any mix are remotely selected on a panel control board. After that, feeding from storage to the scale, weighing and discharging from the scale proceed automatically. The process repeats itself as many times as need be.

In addition to high weighing accuracies, the new installation can turn out 20 batches per hour which includes a 28-second mixer discharge time. In the mixing cycle, carbon black is screw-fed from individual bins to a receiving hopper made of stainless steel and equipped with a vibrator to prevent material from settling on the walls. As carbon black drops into the hopper its weight is indicated on a large scale dial beside the control panel. When selected weight is reached the dial triggers an electric mechanism, and feeding stops. Then another carbon black is weighed until the correct amount is indicated. The process is automatically repeated until the formula is completed.

Progress of the weighing operation may be followed by observing lights on the panel, *Fig.* 2. If anything should go wrong during proportioning, the system shuts down, alarm lights inform the operator of the trouble and where it is located.

While eight carbon blacks are used in the overall operation, no more than four are used for any one formula. Consequently, the control panel is equipped with four weight selectors but any one of the four can be used to select any of the eight blacks. Important feature of the control panel is provision for manual operation at any time, during any step of the proportioning operation.

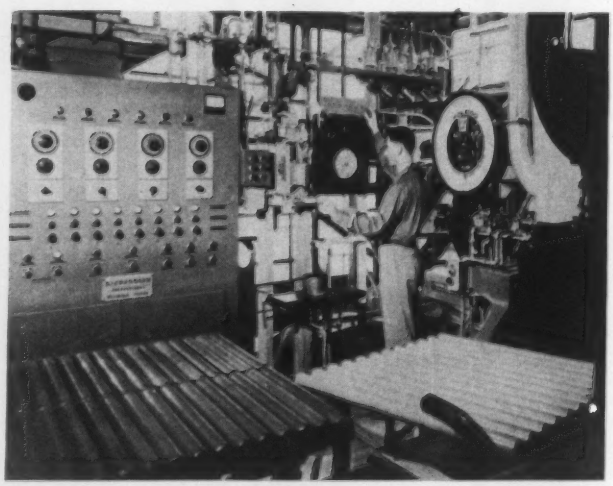
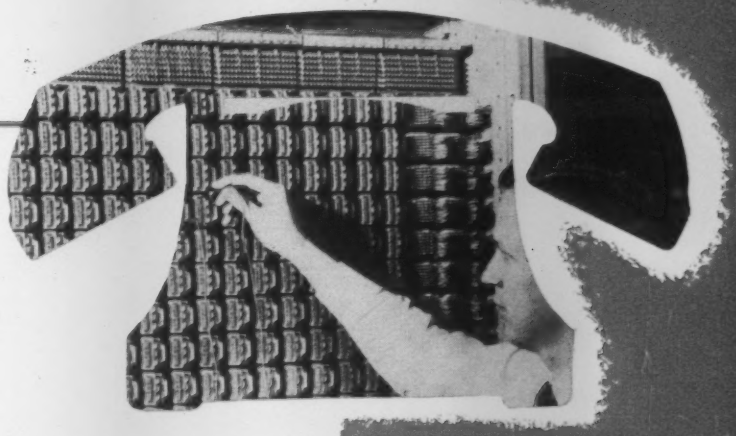


Fig. 2—Checking Bristol controller, operator observes progress of mixing cycle. Conveyors in foreground handle slab stock that is weighed on the adjacent scale and manually dropped into the Banbury. On left is control panel for carbon-black proportioning system



BETTER, LOWER COST
TELEPHONE RELAY HIGHLIGHTS

DESIGNING FOR AUTOMATIC PRODUCTION

By H. M. KNAPP
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Bell Telephone Laboratories Inc., New York

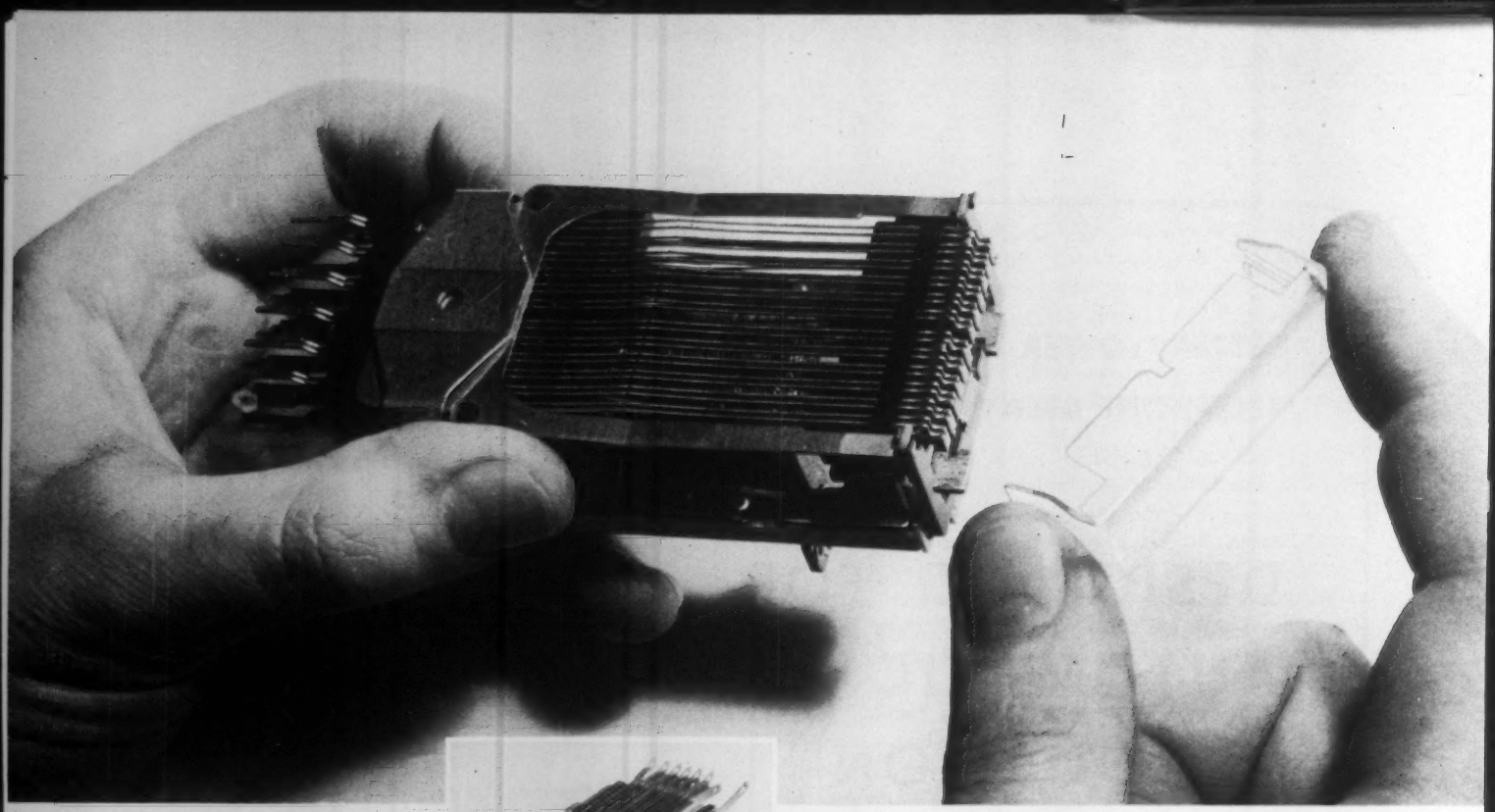
Relays constitute one of the key "building blocks" in telephone switching equipment. Here automation in production aids automation in telephone service. Good design for mechanized manufacture at lower cost has resulted in a relay with more reliable performance, lower operating and maintenance costs and longer life

GENERAL-PURPOSE RELAYS constitute the most repetitive "building blocks" in telephone switching equipment. It is logical, therefore, that these relays should be under constant study to provide more reliable performance, low manufacturing, operating, and maintenance costs, and longer life. New design procedures and improved manufacturing methods have resulted in a new relay that has shown considerable improvement over the older relays in attaining the desired objectives.

One of the recent major developments of Bell Telephone Laboratories and the Western Elctric Co. is the wire spring general-purpose relay, *Fig.* 1. Its first application is in the No. 5 crossbar system, which is being modified to use the new relay in place of the former U type relays. Substantial economies in manufacture, operation, and maintenance are anticipated with the wire spring relay.

Basically, the telephone relay performs a relatively simple operation in closing and opening contacts. Because relays appear so often in telephone circuits—in the order of 60,000 in a 10,000 line crossbar office—they become one of the most important components of telephone switching systems. For this reason, and because these systems are constantly undergoing improvements, studies directed toward improved relays have been carried on for many years, taking advantage of improved designs, newer materials, and better construction

Article, courtesy Bell Laboratories *Record*.



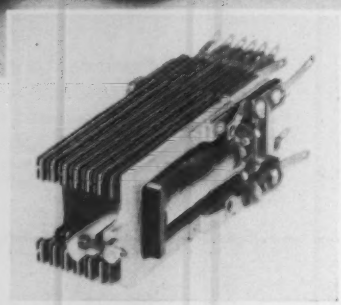


Fig. 1—(Above) New wire spring relay which was redesigned for mechanized manufacture

Fig. 2—(Left) Old style U-type relay of flat spring design

methods as these develop. The new wire spring relay will be cheaper to manufacture, faster in operation, require less power, have longer life, provide improved contact performance, and require less maintenance than earlier types of relays not adapted to automatic production.

▶ Low-Cost Automatic Production

At first glance, it is not immediately apparent why the wire spring relay should be cheaper to manufacture. It appears to be more intricate than the flat spring relay, *Fig.* 2, because of the larger number of closely mounted contacts and wires. It is in this construction, however, that a large part of the expected reduction in cost lies. *Fig.* 3 shows a comparison of the springs and insulators needed for a contact arrangement consisting of twelve normally open contacts. For the U type relay, fifty four individual parts must be assembled by hand to provide the contact assembly; for the wire spring relay, two molded subassemblies of wire springs accomplish the same purpose.

It is, of course, important that the subassemblies be produced and assembled at a cost below the corresponding cost for the U relay. Production of these subassemblies is accomplished by mechanized manufacture in which the necessary number of wires are fed through straightening dies into the molding press in a continuous automatic operation. Wire spring assemblies are shown in *Fig.* 4 as they come from the molding press and prior to cutting to length and welding contacts to them. Since a contact pair consists of a stationary contact mating with a pair to twin contacts, two kinds of wire assemblies are required. After cutting to length, these assemblies are passed through another line of automatic operations in which the wires are formed to provide tension and offsets, the contacts are welded to the wires, and the terminal ends tinned.

▶ Simplified Design for Manufacture

Another feature that contributes to lower manufacturing cost is the similarity of parts of the relay regardless of the ultimate application. The eleven standard parts of the relay are shown in *Fig.* 5. These can readily be assembled without using screws, a factor in itself that contributes to lower assembly costs. The relationship of these parts is shown in *Fig.* 6. A special jig, illustrated in *Fig.* 7, has been devised for use in the laboratory to assemble the relays. In this assembly, the clamp that takes the place of screws in holding the relay together, must have sufficient clamping force to insure a stable relay. *Fig.* 9 shows the laboratory setup for checking the tightness of the relay assembly.

For maximum economy in manufacture, it is de-

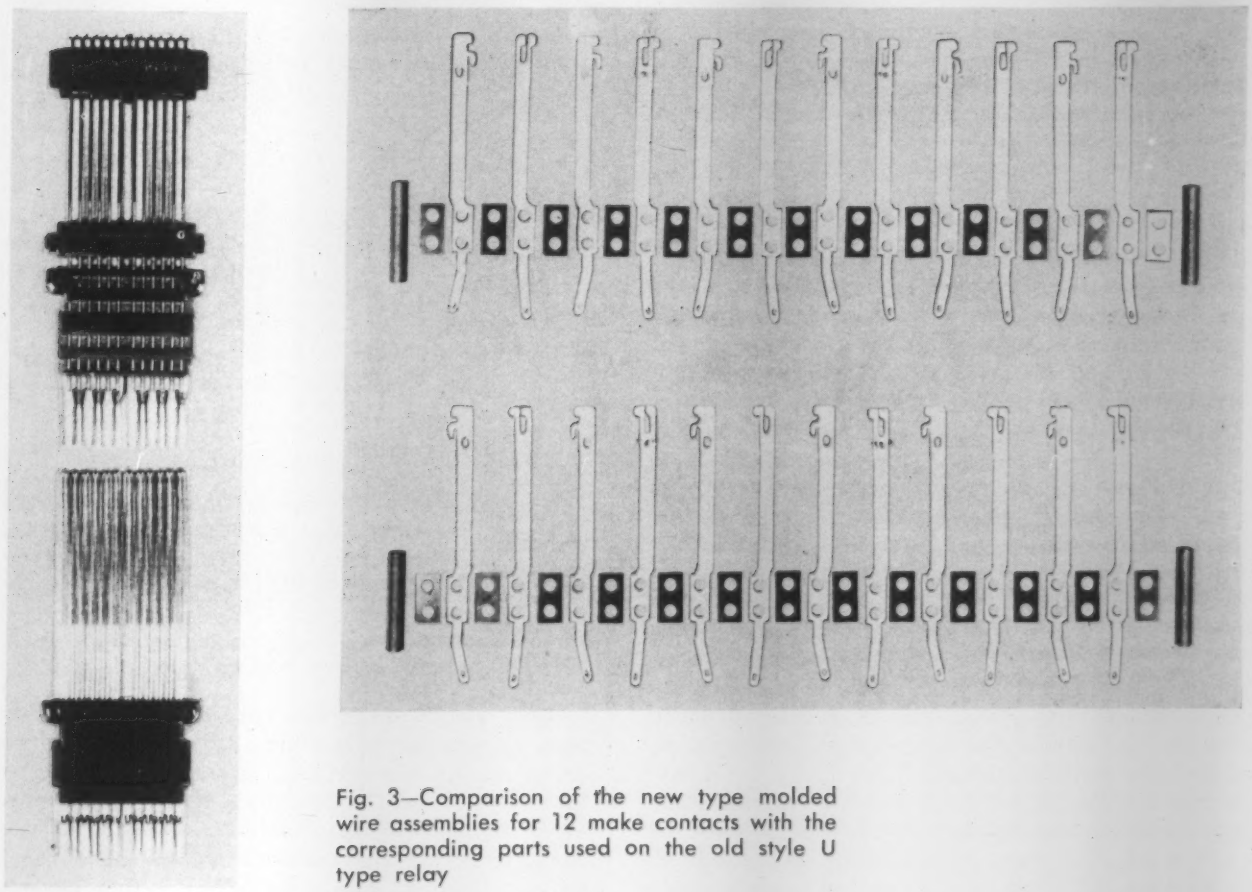


Fig. 3—Comparison of the new type molded wire assemblies for 12 make contacts with the corresponding parts used on the old style U type relay

sirable that the number of different types of relays he held to a minimum. Circuit requirements, however make it necessary to provide a wide variety of contact combinations. These combinations consist essentially of those that are normally-open (make), normally-closed (break), or sequences of both of these, such as "break before make" (transfer) and "make before break" (continuity).

In the wire spring relay, it is possible to combine these relatively simple fundamental arrangements to obtain a wide variety of spring combinations using few parts. A phenol fibre card, which can be seen on the front end of the relay in *Fig.* 1, is used to operate the contacts. The moving contact spring of a make contact is tensioned against one edge of the card, as shown diagrammatically in *Fig.* 8*a*. When the armature of the relay operates, the card moves with it, permitting the moving contact to touch the stationary one. In the case of a break contact, the tension of the moving spring is against the stationary contact, and the card moves to separate the contacts when the armature operates, as indicated in *Fig.* 8*b*. Sequences between make and break contacts are obtained by the use of shoulders or steps in the actuating edges of the card, as illustrated in *Fig.* 9.

Equally important in keeping manufacturing costs low is reduction of adjusting effort. In the

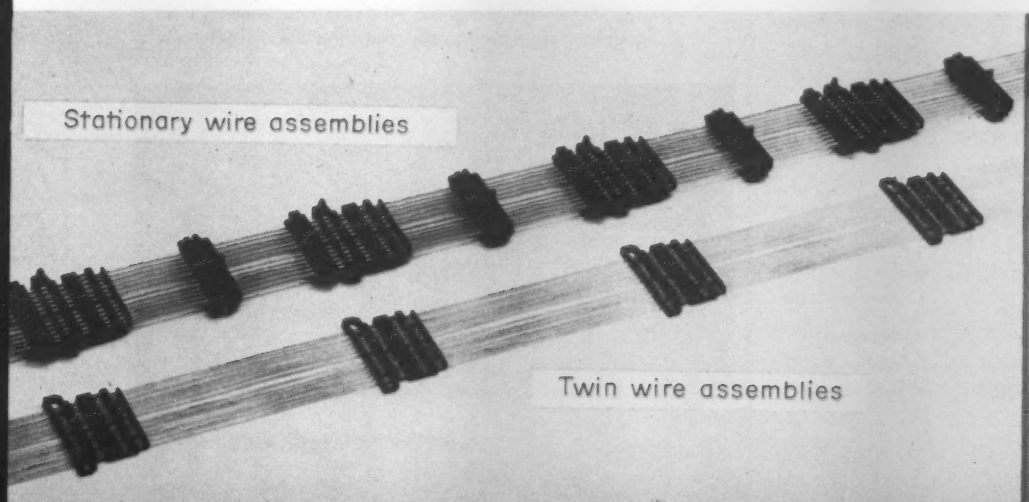
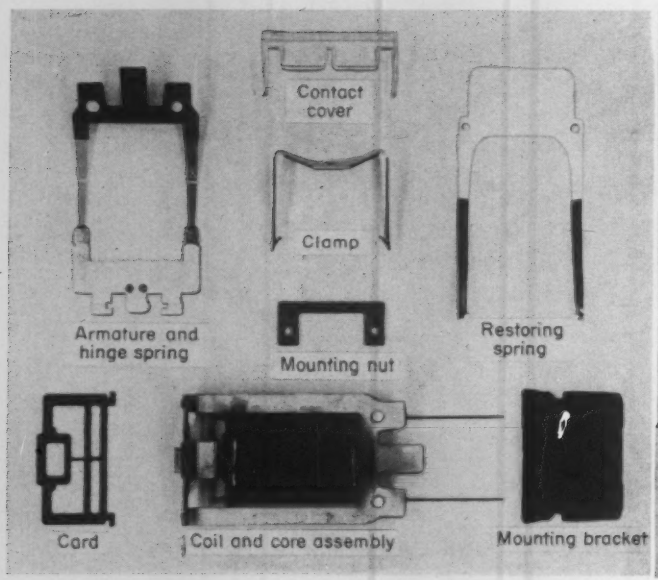


Fig. 4
Molded stationary and twin wire assemblies before cutting to the proper length



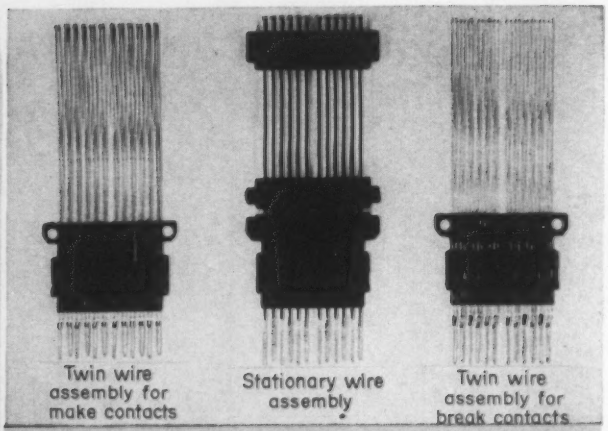


Fig. 5—The eleven standard parts of the wire spring relay

wire spring relay, by its design and construction, avoids both hand tensioning and positioning of the individual contact springs.

Elimination of hand tensioning is accomplished by machine-forming suitable bends in both the single and twin wires, the restoring spring, and the armature hinge spring. These are readily visible in *Fig.* 6. The bend in the single (stationary) wires holds the front molded block in position against the core plate. The tension provided by the bends in the armature hinge spring positions the armature and provides tension at the hinge point against the core legs. Tension of the restoring spring keeps the make contacts open when the relay is unoperated, and holds the armature against its backstop with a suitable force. The bends in the twin wires provide the required contact force. Control of the tensions is accomplished primarily by large predeflections, as indicated in *Fig.* 10.

Similar pretensioning of contact springs is being applied to the U relay, but manual bending of individual spring tangs is still needed to position the contacts properly. On the wire spring relay, however, this operation is avoided by minimizing the number of dimensions controlling the operation of the contacts and by close control of these dimensions during manufacture.

Close control of contact position during manufacture reduces to a minimum the adjustment required on the new relay. It is the design objective that only a small fraction of the relays may require adjusting, and this is in the form of a gang adjustment, in which the contacts are positioned as a group. Contacts can be gang adjusted to operate at the proper point in the armature travel by bending the arms of the core plate with a screwdriver, *Fig.* 11. This positions the stationary contact relative to the core. The armature restoring springs, shown at the top in *Fig.* 6, are pretensioned, and may frequently need no adjustment, but when this is required a simple spring bending tool is used.

In fastening the new relay to its mounting plate, two screws engage a tapped U-shaped detail indicated in *Fig.* 5 as the mounting nut. During assembly of the relay, this nut is inserted in a recess of the mounting bracket, *Fig.* 5, where it is trapped when the bracket is assembled in the relay, *Fig.* 6. This construction insulates the core and armature from the mounting plate, eliminating the need for the insulators that were used for this purpose with the older relays.

Fig. 6—Top view of the relay showing the locations of the several parts

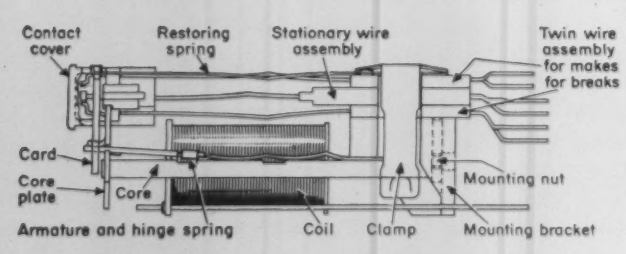
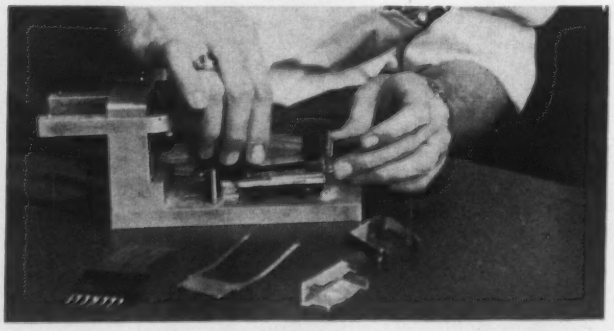


Fig. 7—Assembling an AF type relay in a special jig designed for the purpose



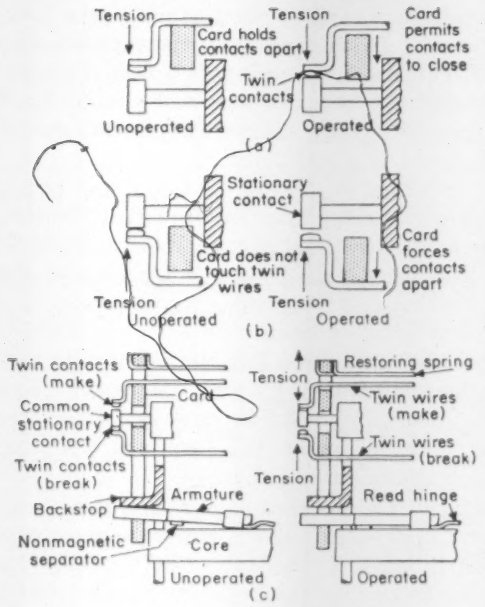


Fig. 8—Principles of operation of (a) make contacts, (b) break contacts and (c) transfer contacts

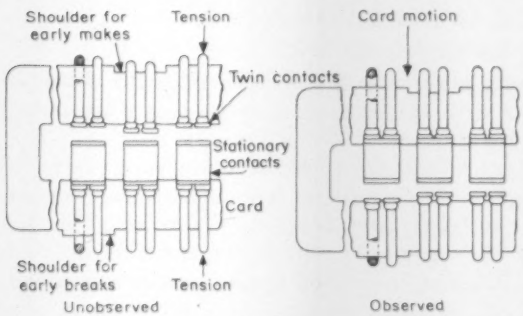


Fig. 9—Sequences between making and breaking contacts are obtained by means of shoulders on the actuating card

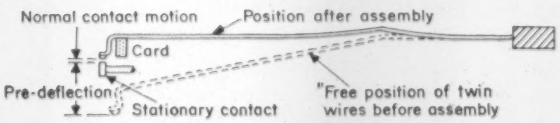
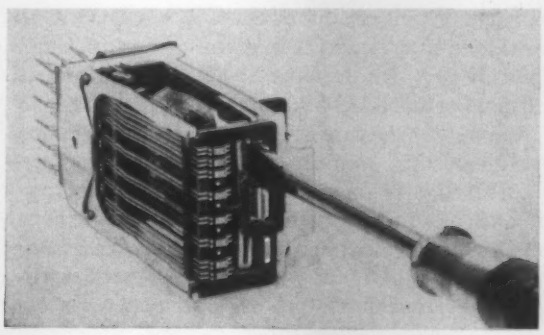


Fig. 10—Contact forces are controlled by relatively large predeflections of the twin wires

Fig. 11—Contacts may be gang adjusted by bending the arms of the core plate with a screwdriver



▶ Improved Functional Details

Instead of using a cover over the entire relay or group of relays, a molded transparent contact cover is provided for individual relays. Its prime function is to protect the contact from dust and dirt and to retain the moving contact wires in their individual guide slots, which are molded into the front section of the stationary wire block. This cover may be put in place in the final assembly operation, and need not be removed through subsequent inspection, adjustment, wiring, shipping, installation and use of the relay. Of cousre, in clearing circuit troubles during manufacture, installation and use, the cover may readily be removed for access to the contact springs. There is good reason to believe that with the protection afforded by this cover, together with the use of completely independent twin palladium contacts, open contact troubles should be reduced greatly. The contact covers also avoid the need for frame covers or common can covers now employed in the various switching systems.

Reduction in sticking contacts is anticipated because of the method of actuating the contacts. This method is similar to that of the UB relay, in which relatively large restoring forces are applied close to the contacts, by means of the actuating card. Another feature of this method of actuation is that a uniform contact force is obtained, even though wear of the contacts and other relay parts takes place. A comparison of the decline of contact force due to wear on the U relay and on the wire spring relay is shown in *Fig.* 12.

Of major importance in speed and capability of operating a large number of contacts, is the efficiency of the electromagnet. This efficiency contributes also to lower power consumption. The magnetic structure of the wire spring relay is shown in *Fig.* 13. The central core, on which the operating winding is mounted, is the center leg of a flat, punched, E-shaped member, and the outside legs serve as magnetic return pole pieces. This one-piece construction minimizes the reluctance of the magnetic circuit.

The armature is a flat, punched U-shaped member that bridges the three legs of the core. The armature illustrated in *Fig.* 13 is used on the AF type relays and is made relatively short to aid in obtaining high speed and to reduce rebound.

For maximum efficiency of the magnet, all three mating surfaces of the armature and core must be closely aligned. As an aid in doing this, a punched detail called a "core plate," is forced over the ends of the core, *Fig.* 14. This core plate also provides a back stop for the armature.

▶ Standardization of Components

Switching circuits require that relays differ widely in their operating characteristics; some must be fast operating, some slow release; others must operate, hold, or release on certain values of current within rather limited ranges. Still others must

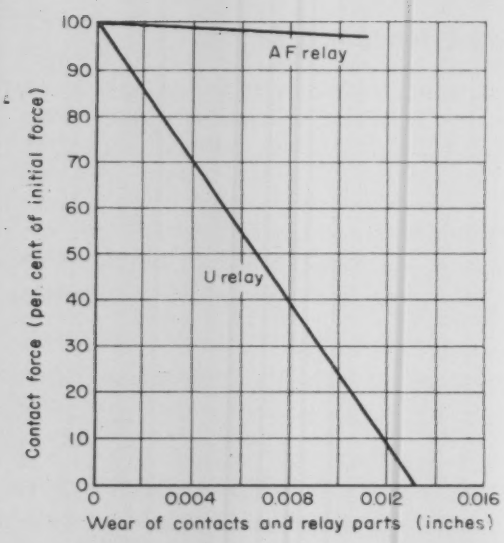


Fig. 12—Contact forces on the wire spring relay remain almost constant for limited amounts of wear. On the U relay however, contact forces drop rapidly with wear

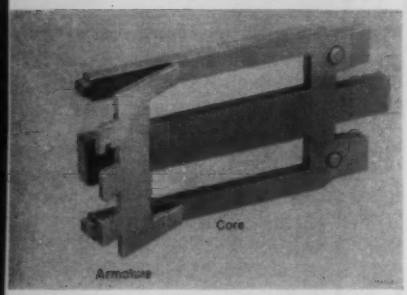


Fig. 13—The magnetic structure of the AF wire spring relay. A relatively short armature aids in obtaining high operating speed

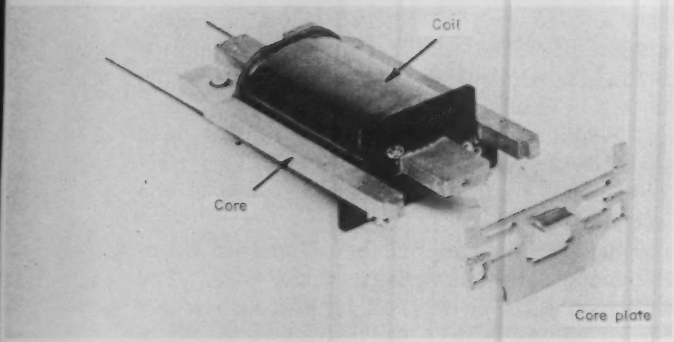
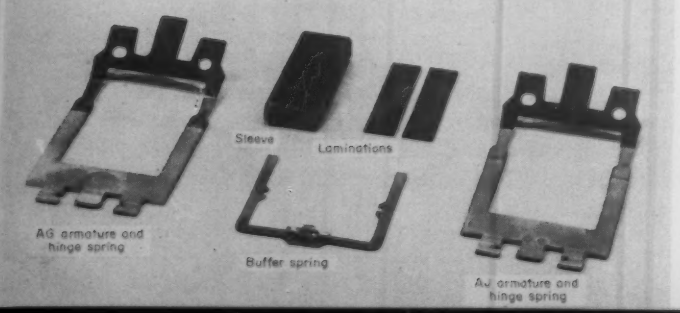


Fig. 14—After the coil is assembled to the core of the relay, a core plate is forced over the ends of the core legs to hold these legs in alignment

Fig. 15—Additional parts used on the wire spring relay to aid in obtaining different operating characteristics



have high sensitivity; they must operate on a minimum of power. To build these characteristics into the general-purpose relay and still retain the principle of mechanized manufacture and standardized assembly requires that differences in design of parts be reduced to a minimum.

Much can be accomplished toward these objectives by merely varying the design of the coil, that is, selecting the wire size and number of turns to meet the particular circuit needs. High speed, for instance, can usually be obtained by the use of a low-resistance winding having an optimum number of turns; sensitivity, by using full windings containing a large number of turns. There are cases of severe circuit requirements, however, where the special windings must be supplemented by other changes and additions to the relay.

For example, assume that a more sensitive relay or one having greater pulling power than that of the standard wire spring relay, is needed. An armature as shown on the right in *Fig.* 15, which is longer than the one normally used, provides lower reluctance in the magnetic circuit. Laminations are added to the center leg of the core (under the winding) to provide greater core section. Because of the relatively small demand for such relays, it would not be economical to provide this thickness of core for all relays.

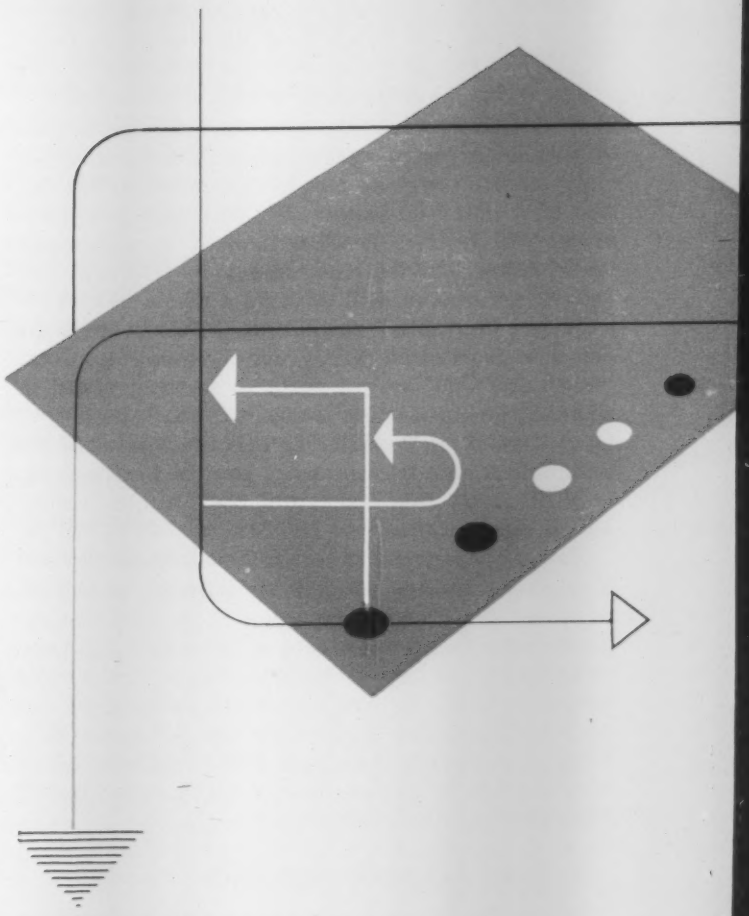
To meet slow release requirements, the relay is equipped with a long armature having a spherical embossing where it engages the core, similar to the Y type relay and a copper or aluminum sleeve is used under the winding. To control the release time, a buffer spring is used, which adds to the load on the armature during its last few mils of travel. Slow release wire spring relays are coded in the AG series; marginal and sensitive relays are coded in the AJ series; others AF.

Other Advantages

Besides aiding the pulling capability of the new relay, the magnetic circuit has the advantage of reducing external flux leakage to a negligible amount. Consequently, equipment precautions such as large spacing of relatively critical relays, or the use of magnetic shields are no longer needed to avoid magnetic interference from adjacent relays. This in turn saves mounting space; for example, in the No. 5 crossbar intra-office trunk circuits, equipment for two trunks will now mount on two mounting plates instead of three, as required by U relays. Because of the higher speed attainable with the wire spring relay, common control equipment is able to handle more calls in a given period of time, thereby reducing the amount of control equipment such as markers needed in a central office. This is a very important advantage economically because of the high cost of markers and associated equipment. Besides, the new relays are capable of operating approximately twice the number of contacts as the older relays, so that one relay can take the place of two in many applications, with a resulting saving in relays, power, and space.

FEEDBACK CONTROL SYSTEMS

FOR AUTOMATIC OPERATION



True automatic control depends on feedback. Sometimes complicated in design, such systems are simple in concept. Here, in easy to understand language, is what you need to know

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PURPOSE of this article is to set forth in non-mathematical language certain fundamental concepts of automatic control systems required in the field of industrial automation. One does not need to be capable of designing such systems in order to have a talking knowledge and appreciation of their application and possibilities. It is true that in design certain aspects of automatic control systems require ability in the field of advanced mathematics and physics, but these are not necessary to understand how such systems are applied and function.

Industrial administrators and executives will sooner or later be exposed to the question of what processes or items of manufacture, if not the entire factory, might be automated. If this be the case, certainly a broader conception of one critical phase of the matter, which is feedback control, will be enlightening and necessary in order to discuss and understand the significance of many automatic control systems under consideration.

Automation—A New Era

Much attention is being given to automatic control systems by the popular, technical, and trade press, especially in regard to their influence on automation in industry. There are many prognostications being made about the factory of the future, and much consideration is being given constantly by management to the possibilities of making processes or machines fully automatic.

Industry's great need is to increase the productivity of labor, enabling the worker to produce more and better products with less effort under

more pleasant working conditions to the benefit of both labor and management. The use of automatic controls will be further exploited to the extent that many of tomorrow's processes and operations will be performed with little or no human intervention. There are some who feel that the field of automation will open up a whole new era—a second industrial revolution. This is perhaps closer to realization than generally thought. Complete automatic control systems are costly and in some cases exceed the cost of the machine proper many times. In considering existing processes for automation, the cost of most control systems can only be justified if the initial cost can be written off on mass production.

The big future lies in technological areas wherein a process requires control of chemical exchange, temperature, pressure, speed, etc., beyond the capabilities of human operator adjustments and comprehension. In other words, the trend towards automation will not be one of economy alone, but of sheer necessity required by the future development of products, materials and operations which might never become a reality without the benefit of modern control systems.

Basic Automatic Operation

The subject of control systems, like its language, is a broad one. The control of a process or machine may be manual or automatic, and the terminology and language used holds different concepts of meaning and function for different people. Broadly speaking from a process standpoint, if it is required of an operator to start, stop, adjust speeds, temperatures, flow rates, etc., by pushing buttons or turning control knobs, the process is manual regardless of how many switches, relays, electronic tubes, or other complicated control elements may be interposed between the operator and the final controlled quantity.

An automatic process or machine is one in which no human intervention or judgment is required once the process or machine has been started. Under automatic systems there is a differentiation between that which is merely automatic operation and that which is automatic regulation. The automatic sequencing and timing of, say, the various steps in an automatic plating process is an example of automatic operation, as there is no manual regulation of the process involved. Once the sequence and timing cycle has been initiated, the process goes through its predetermined steps of the cycle no matter what the quality or quantity of the product output. In such automatic systems there is no attempt made to measure the process output performance and make corrections accordingly. However, automatic regulation of a process or machine involves the principles of feedback control. Such a system measures output performance in a manner so as to feed back information to a stage of the input regarding the difference or departure from the desired value and to cause a correction to be made to restore the process to its desired value. As an example, such systems are used in paper mill drives to hold accurate control of speed over the entire range of speed and load disturbances.

It is this type of true automatic control which has made possible the development of fully automatic processes and machines to a high degree of precision and speed. The heart of this type automatic control is the principle of the closed loop or feedback control, making possible automatic regulators and position controls in many industrial applications as well as the integration of multitudinous automatic sequences through computers or information machines.

Types of Control Systems

Under the progress and development of automatic control systems there have evolved two types of control:

1. Open-loop or open-ended system.
2. Closed-loop or feedback system.

In order to obtain an early appreciation of the difference between the two, a homey and elementary example will be used.

The well-known problem of thermostatically controlling home temperature is an example of the earlier and simpler concepts of automatic control and at the same time provides an excellent introduction to the newer concepts of automatic regulation. If you attempted to control the temperature of your home by the use of an outside thermostat to start and stop the oil burner in accordance with the weather outside, it would be an open-loop or sequence control, as there is no reflection of the inside room temperature on the outside thermostat. There is no interrelation; there is no feedback. Such a system would give extremely poor room temperature regulation because it would be difficult and impractical to calibrate for cold winds and room heat losses.

On the other hand, if the outside thermostat were relocated to the inside of the house, the system becomes a closed-loop or feedback system in its simplest sense since there is a reflection of room temperature on the inside thermostat. The system will regulate the room temeprature in accordance with the desired set value regardless of external influences.

There is an important difference between the two systems. In the open loop there is no measurement of the control operation results, and nothing is done in the system if the desired results are not obtained. Crudely speaking "you get what it gives." Open loops are calibrated systems requiring careful testing, calibration, and maintenance in order that they perform properly. They initiate automatic operations but do not regulate themselves. On the other hand, closed-loop or feedback control is a system of automatic regulation wherein information regarding the output is fed back

into a stage of the input in order to regulate the output.

An interesting point here is that there must be an error or deviation from the desired value to effect a correction—of course this error is kept to a practical minimum. Feedback controls are self-regulating, continuously and automatically readjusting for all conditions of disturbances and upsets and give more accurate results with less attention than the open-loop system.

Hunting in Feedback Systems

There is one peculiarity of feedback control which is not associated with open-ended systems and that is a phenomenon known as hunting or the tendency towards self-oscillation. The minimizing of this instability without affecting desirable characteristics represents a challenge to the designer of feedback systems, particularly if the system is a rapid response, high-accuracy servomechanism. However, it should not be inferred from this that oscillation, when present, constitutes an undesirable or an inoperable condition. There are systems in operation in which oscillation is present, is encouraged, and is controlled.

Peculiarities of hunting in closed loops basically come about by the feeding back of delayed output information into the input. When there is an output disturbance of the regulated device, it is reflected in a suitable measuring device which will send a difference or actuating signal by the amount it differs from a reference quantity. This actuating signal will cause the controller to change the regulated quantity and it may overshoot, depending upon the various lags in the process, control system, or by reason of the storage of energy and its release after a lapse of time. The controller then tries to correct the overshoot and as a result it undershoots. This overshooting of output above and below the desired value causes its recovery to become oscillatory and under certain conditions may even become increasing in amplitude. It is interesting to note were it not for mechanical or electrical time delay there would be no hunting.

Standard Terminology

In order to clarify the context of the above generalization of open and closed-loop systems, the block diagram of *Fig.* 1 will be used to help explain these points. It may be well to point out that literature on servomechanism and feedback control systems has been most confusing by the use of language and terminology as varied as the authors. There has been a need for standard terminology and nomenclature in order that a common language might develop for the benefit of all in-

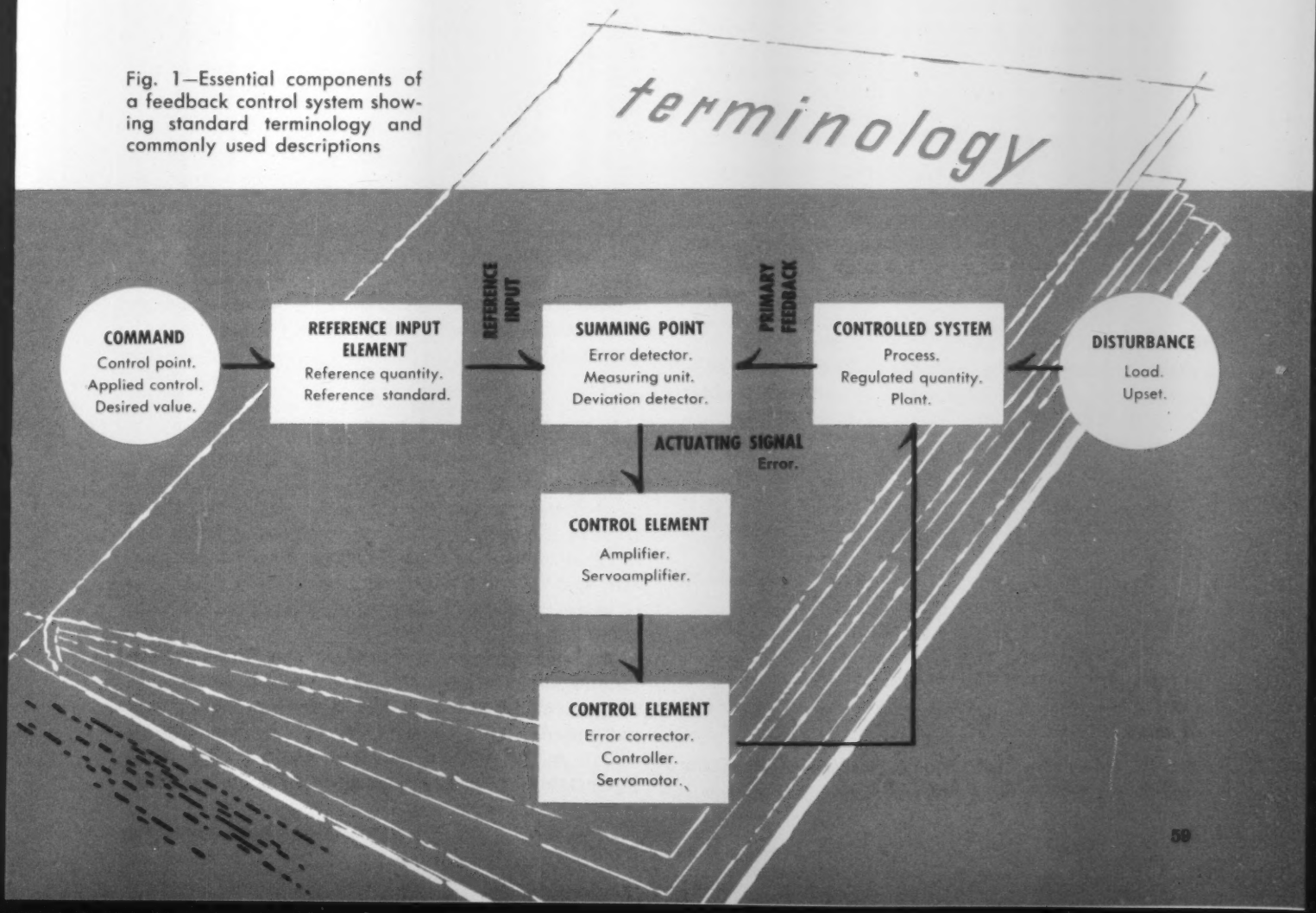


Fig. 1—Essential components of a feedback control system showing standard terminology and commonly used descriptions

terested in this subject. Dissemination of proper information will aid in the development and popularization of automatic feedback control systems in industry.

The AIEE feedback control committee has attempted to develop such in their "Proposed Standards" published in *Electrical Engineering*, October 1951. In *Fig.* 1, the standard terminology is shown. In parentheses are some of the many other descriptions of these functions that have been used in the past.

Whether you describe an automatic control system as a closed-loop, closed-end, closed-sequence, servomechanism, or regulator system, they are similar in that they function on the same general principle. As indicated in *Fig.* 1, this is a feedback power amplifying system, of automatic self-regulating control in which the controlled system is being constantly matched or compared to the reference input element. A servomechanism is not a device but rather a classification of feedback control involving a particular function. In consequence, this type of automatic control function is now being referred to more generally as feedback control. As feedback is the heart of the matter, the word is self-explanatory.

AIEE has defined a feedback control system and a servomechanism as follows:

1. A *feedback control system* is a control system which tends to maintain a prescribed relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control.
2. A *servomechanism* is a feedback control system in which the controlled variable is mechanical position.

Every feedback control system is not necessarily classified as a servomechanism. By definition, the word servomechanism is reserved for such systems wherein the position of one member will change to match the position of a second member whose position may vary in a random manner due to external influences, such as on a profile cutting machine or temperature recorder of the balance-slide wire type. On the other hand, a feedback control system which basically tries to hold or regulate one variable quantity so that it matches a fixed reference quantity rather than a variable one, such as maintaining a constant voltage or frequency, is known as a regulator. While every servomechanism incorporates feedback control, every feedback control system is not a servomechanism.

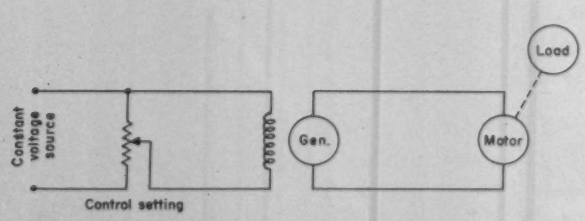


Fig. 2—Elementary open-loop speed controller of the adjustable-voltage Ward Leonard type

Components for Feedback Control

The block diagram of *Fig.* 1 shows the function of a feedback control system. Each of the blocks serves a special purpose in maintaining the controlled system (regulated quantity) matched to the reference input element (reference quantity). The summing point (error detector) measures to what extent the controlled system differs from the reference input element. The difference is sent out as an actuating signal (error signal) to the control element (power amplifier) which then amplifies the small signal to one of sufficient power to actuate the control element (error corrector). The control element then changes the controlled system (regulated quantity) until it matches the reference input element. The closed loop made up by the summing point, control element and controlled system represents the famous feedback which is common to all so called closed-loop, servomechanism, or feedback automatic control systems. The disturbance (upset) such as a load variation and the command (desired value) such as a setting of control, either manually or automatically for desired speed, are shown as independent external influences that upset the balance between the controlled system and the reference input element.

It is possible to regulate any quantity such as speed, frequency, temperature, position, torque, direction and voltage. Similarly, any quantity may be used as a reference standard. The reference input unit need not be the same as the controlled system unit as long as they are made compatible; that is, if speed and temperature are being matched the two units can be converted to a voltage base through suitable transducers. For example, the temperature can be converted to a voltage through a thermocouple and the speed to a voltage through a tach-generator.

Feedback Control of Speed

The practical problem of automatic speed control as required for reeling drives for paper machines, rolls in the rolling mills, and textile machines will be used to illustrate the function of a feedback control system. Speed control was selected because it is more readily visualized and comprehended than other forms of control.

Basic control system used in the following examples is the Ward-Leonard adjustable-voltage arrangement, as shown in *Fig.* 2, for controlling output speed. This consists of the familiar MG set and a motor with a constant excited field. The potentiometer in the generator field controls the

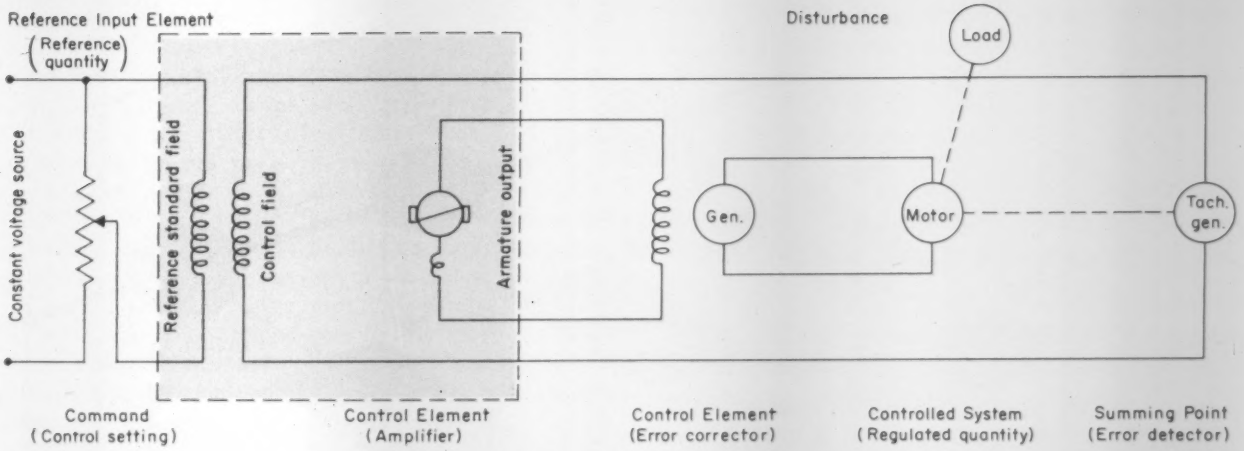


Fig. 3—Automatic speed regulator with feedback system having self regulated output speed

armature voltage, and hence, the speed of the motor. This being an open-loop type control, the output speed will not necessarily follow the potentiometer control setting, due to inherent characteristics, heating, load, and other effects. Speed regulation will depend entirely upon the inherent characteristics of the generator and motor. In order to maintain a constant speed under varying load conditions, a closed-loop or feedback control system must be used.

A feedback control method of self-regulating output speed of a motor under varying loads is shown in *Fig.* 3. Using the basic adjustable-voltage arrangement of *Fig.* 2, it is possible to change from an open-loop to a closed-loop system by the simple addition of a tach-generator and a special dc exciter which is in effect a rotary amplifier. The relationship between the block diagram, *Fig.* 1, and the components of the feedback control of *Fig.* 3 is indicated where applicable. This may be called an automatic speed regulator or feedback control system for maintaining a constant motor speed. Again, the output speed of the motor is controlled by the voltage applied to its armature through the generator whose field is now excited by the rotary amplifier. This device uses a reference standard field, the reference being a constant voltage source, and a control field excited by the tach-generator. For simplicity and ease of visualization the reference standard field and the control field are shown as separate fields.

It is possible to combine the function of these two fields into one by other circuit arrangement. The control field and the reference field are balanced when the motor speed is at the desired value. Any deviation from the desired speed causes a corresponding change of the tach-generator voltage and the resultant field of the rotary amplifier in such a direction that the proper correction voltage is applied to the generator field, thereby changing the motor speed. The tach-generator (summing point), rotary amplifier (control element), generator (control element), and the motor (controlled system) make up the closed loop, characteristics of all feedback systems.

As previously noted, a peculiarity of feedback control systems is their tendency to hunt or become self-oscillating because of electrical or mechanical

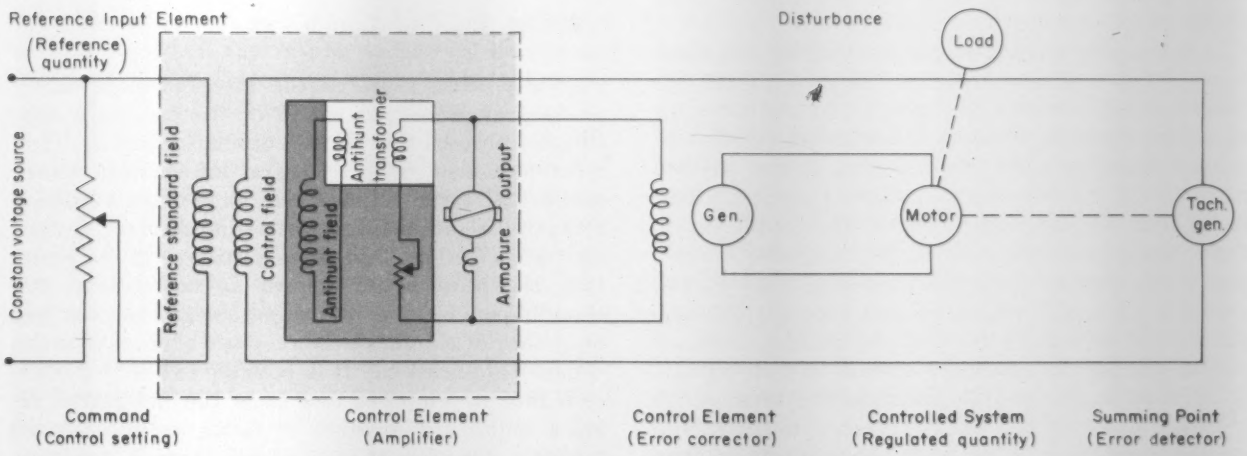


Fig. 4—Automatic speed regulation feedback system with anti-hunt provision. Color shading indicates packages of elements

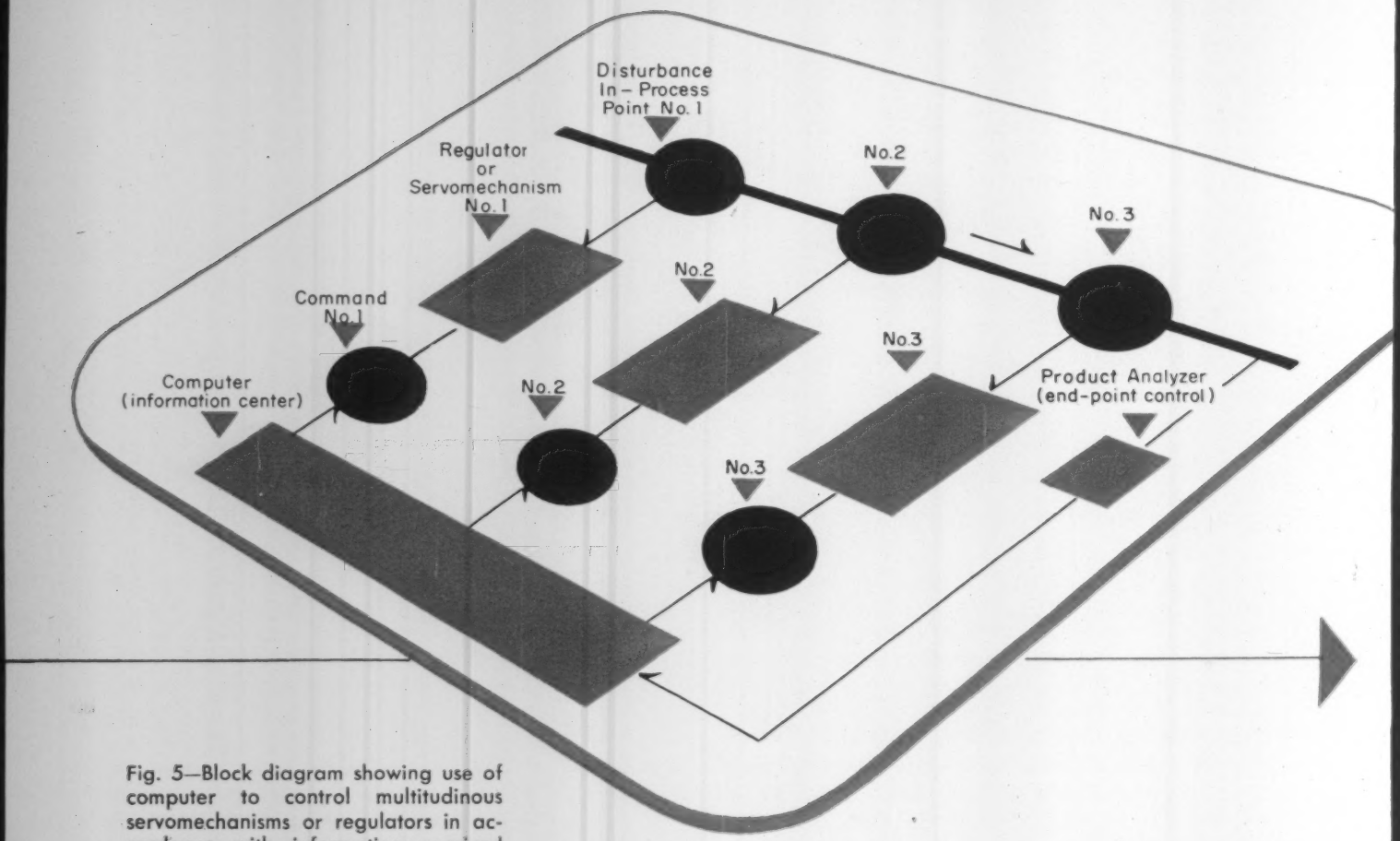


Fig. 5—Block diagram showing use of computer to control multitudinous servomechanisms or regulators in accordance with information received from product analyzer

delays in the system—electrical inductance and capacitance or mechanical inertia that may be interposed in the system between the control element (amplifier and error corrector) and the summing point (error detector). The inertia which must be overcome before correction is obtained is responsible for control supplying too much correction causing overshooting or hunting. The more critical the requirements of sensitivity, speed of response and accuracy, the greater the tendency to hunt. This is the phase of feedback engineering requiring the most rigorous mathematical treatment and analysis all of which can become complicated.

It is possible to correct for hunting by introducing certain antihunt circuits. However, each requires careful study in order that satisfactory transient response be achieved without sacrifice of system stability. *Fig.* 4 illustrates one of several methods of introducing damping or antihunt features into the automatic control system of *Fig.* 3. Still using the versatile rotary amplifier, sometimes referred to as a multiple-field exciter, and introducing another field excited through the secondary of a transformer whose primary is connected across the armature circuit output voltage, it is possible to provide antihunt features.

In antihunt circuits the feedback is negative and proportional to the rate of change rather than change alone. As long as the output voltage is constant, no voltage is induced in the secondary winding of the transformer, hence no current flows through the antihunt field. However, if the output voltage changes, a voltage is induced in the secondary winding of the transformer which is proportional to the rate of change of the output voltage, hence a current will flow through the antihunt field, the magnitude of which is also proportional to the rate of change of the output voltage. The polarity is made negative to the control field so that it opposes too rapid changes in the output voltage.

▶ The Role of Computers

If a process requires the integration of many feedback systems, as would be the case in a continuous process line in an automatic factory, they must be collected by a central information center which, in turn, adjusts the individual feedback systems in accordance with the product output analysis. The genii in these cases are the information machines better known as computers. Although popular use of computers in the past has been that of computation, they are capable of much broader application. It is possible to feed information into a computer and have the integrated results make any number of loops or mechanized controls function in accordance with a predetermined program. There are two types of computers: (1) Analog and (2) digital. Each has a particular

preference application depending upon the problem of control or calculation.

Briefly, the analog machine is just what its name implies, a system of physical quantities of either mechanical or electrical elements set up to be analogous to the problem under analysis; it is a measuring machine. It has certain disadvantages, as the problem becomes more complex, so does the analog. Its accuracy is limited to that which can be built into its mechanical or electrical elements. However, it does have certain advantages as a computer in that it need not be any more involved than the problem requires. It is direct acting, does not require special and complex input and output devices, and offers instant and continous solution since the analog is the equation of the problem.

The digital machine on the other hand works on an entirely different principle. By handling information in terms of digits, it is a counting machine. The problem must be presented to the machine in its own language. This requires the formalizing of the problem on the basis of mathematical logic or other computational techniques. It has the disadvantage of requiring specialized and complex input and output devices, especially in its application to automatic control. It requires certain basic units of equipment no matter how simple the problem. However, its advantages are many. It is as accurate and precise as the problem requires. Its accuracy is only limited by the significant figures carried. The digital is not vulnerable to mechanical play or electrical noise (disturbance). Therefore, there is no inherent limit to the complexity of problem it can solve. Its speed is fantastic.

Both the analog and the digital computer, separately and in combination, will have wide application in automatic control problems. Each serves some purposes better than the other. However, as the complexity of the automatic control system increases, requiring considerable storage of information (memory), the digital computer will probably be used and as the overall supervisor of the entire process or automatic factory.

▶ The Integrated System

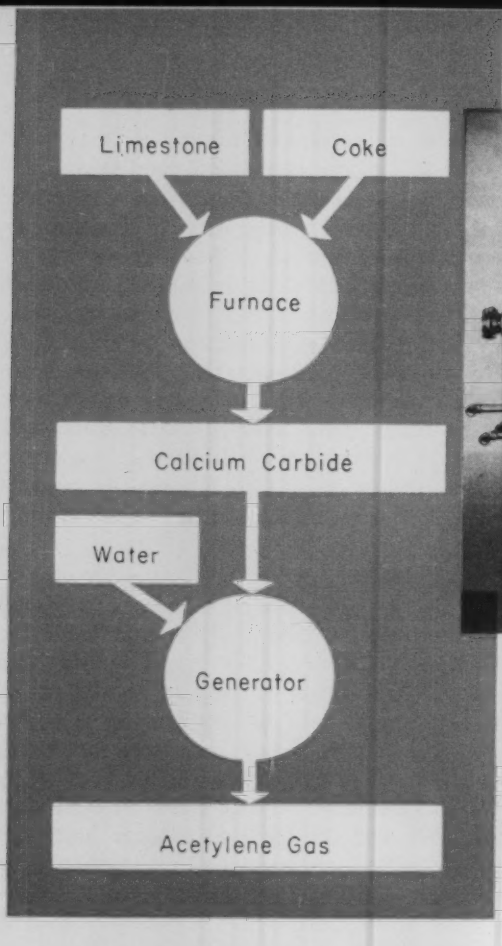
As completely automatic factories and processes are developed in the future, these will be the devices which will extend the realm of the automatic control art, making possible the almost entire elimination of the human element and performing fantastic feats almost beyond belief of speed and quality heretofore known. The block diagram of *Fig.* 5 illustrates in an elementary manner how multitudinous loops may be integrated through the use of a computer and end-point control or continuous analysis of the product output. After the process is in dynamic equilibrium, the condition of overall balance required for trouble-free operation is a continuous one. It is possible to keep it so by end-point analysis of quality and quantity. The computer can determine by how much and at which in-process point an adjustment is to be automatically made to the command of the corresponding servomechanism or automatic regulator to restore the end point to its predetermined condition.

There will be a definite trend toward further automation of industry, especially in continuous processes. In discontinuous or step-by-step processes primary effort will be to automate individual operations where production requirements warrant. The added cost of the investment can be written off on mass production. However, this does not infer that the human element will be entirely eliminated. There will be many cases wherein automation will not be absolute because of prohibitive investment cost or unforeseeable conditions inherent in a process with which the automatic control system cannot cope.

Design of automatic control systems using servomechanisms or feedback systems integrated through computers, product analyzers, suitable input and output information devices, is outside the scope of this article. It is of interest to state that this is a rather new field of engineering wherein the automatic control system engineer does his work on an overall system basis rather than on a narrow, specialist basis. Procedures wherein the control engineer and the instrumentation engineer promiscuously added controls and instruments to the more simple forms of process equipment without particular co-ordination of the entire system will not work for the more sophisticated form of controls of the automated plant where complete overall automatic control system engineering is required. Controls were built around the process or plant, but in the future development of automation the machine or plant will be built around the controls. This will be brought about by the fact that some process developments will be made possible only because of modern control art technique and hence the controls will dictate the machine or process design and layout.

Successful development and design of industrial process automatic control systems requires men of ability in advanced mathematics, physics, chemistry, communications, electronics, circuitry, computational techniques, etc. These are formidable requirements but for those who enter this field there is a big and fascinating future.

As sort of a postscript to this article, it should be noted that in the period of transition from the human to machine control, maintenance will play an even more important part than it does already in today's industry. The best laid plans for automation would fail if these high-investment automatic process systems were out of production even for a short time because of maintenance failure. The maintenance of such systems of controls in their most sophisticated form requires a degree of perspicacity and intuitiveness that may be hard to find. The point to be made is that along with any program of automation should be included the training of selected men to properly maintain the controls and equipment for maximum continuity and output of quality and quantity. Otherwise the added investment for automation will not be justified.



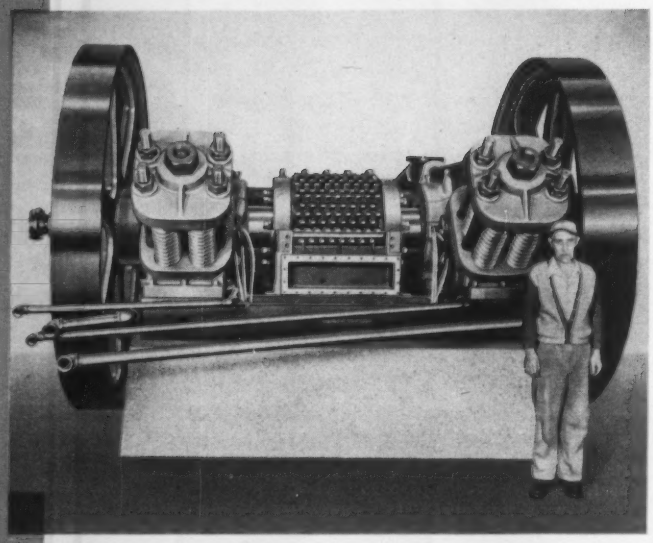


Fig. 2—above—Crusher, designed by Kennedy-Van Saun, with housing removed to show toothed roll. Coil springs provide means for ejection of foreign material such as tramp iron without damaging the roll or anvil. Pipes carry cooling water

Fig. 1—left—Molten calcium carbide from continuous-tap furnace solidifies in shape of ingots. While still hot, ingots are crushed into smaller pieces for feeding to the acetylene gas generator

CONVERSION FROM BATCH TO

CONTINUOUS PRODUCTION

ACETYLENE GAS, widely used since the beginning of the century, has been in increased demand recently as a key chemical in the manufacture of plastic products. Estimates for future requirements prompted investigation into possibilities of continuous process production from calcium carbide. National Carbide Div. of Air Reduction Co. has developed conversion from batch production, with technical assistance from several equipment manufacturers.

Lime and coke come to the Calvert, Ky. plant from nearby areas to charge four 250-ton per day electric arc furnaces. First of their type in this country, these round, continuous-tap furnaces rotate slowly and produce molten calcium carbide which pours into endless belts of ingot molds. Two feet long and six inches square, these ingots cool slowly as they are pulled to the top of the plant and dumped into hoppers for crushing. Fed into a gas generator and mixed with water, the crushed "cake" produces acetylene, *Fig.* 1, continuously.

Ingot cooling time required has limited production in the past because crushing equipment was not available to handle ingots at the high furnace discharge temperature—about 1500 F. In addition to the heat-resistance requirement, the crusher, *Fig.* 2, must handle 30 tons per hour, produce pieces about two inches across and operate without interruption in order to process the output of continuous-tap furnaces.

Critical crusher parts are those in direct contact with the hot calcium carbide cake—the tooth crusher roll and anvil. In addition to withstanding wear at high temperatures, these components are water cooled on inner surfaces, creating a temperature differential as high as 1000 F. American Brake Shoe Electro-Alloys Div. cast Thermalloy is suitable for hard surfacing so that build-up of worn surfaces may be done by welding layers of material to the worn area.

Built by Kennedy-Van Saun, the crusher has moving elements on one shaft, that is, the crusher roll and two flywheels. Weighing five tons each, these flywheels have the momentum necessary for smooth and continuous crushing regardless of changes in feed. Heavy coil springs provide for harmless ejection of foreign material such as tramp iron, and different sizes of product are possible by changing the distance between anvil surface and tips of teeth on the crusher roll.

Performance of the continuous process "pilot" installation has been so satisfactory that conversion from batch production is being extended to three more units.

Second of a series, AUTOMATION presents another section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control.

BASIC CHARACTERISTICS

DELAYING or retarding effects associated with industrial process control are caused by combinations of Capacitance, Resistance, Dead Time and inertial characteristics and have often been designated as various forms of "lag". These four terms cover the basic concepts involved and, in the interest of clarity, should be used to describe the type of "lag" being dealt with. The "lag" concept is generally associated with units of time, but is sometimes associated with units of signal.

201. CAPACITY is a measure of the maximum quantity of energy or material which can be stored within the confines of a stated piece of equipment. It is measured in units of quantity.

The volume capacity of an open tank, for example, is the maximum volume of liquid it will hold without overflowing. The weight capacity of a compressed air tank is the maximum weight of air which it will hold without exceeding safe pressure.

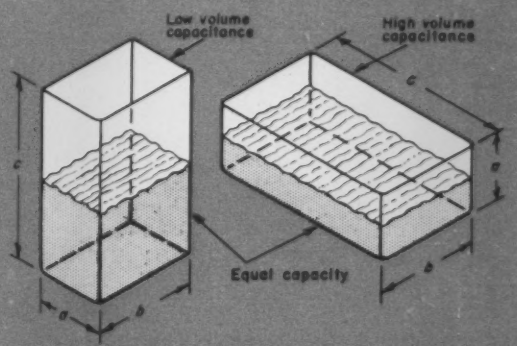
202. CAPACITANCE is the change in quantity contained per unit of change in a reference variable. It is measured in units of quantity, divided by the reference variable.

The energy or material being contained and the reference variable determine the type of capacitance. Process capacitance may involve different quantities and reference variables, and several types may exist together in one process.

The volume capacitance of an open tank with respect to head is the change of volume of stored liquid per unit change of head, which is equivalent in value to the area of the liquid surface. It should be noted that if the shape of the tank causes the liquid surface area to vary with change of head, the capacitance will likewise vary with head.

The weight capacitance of a gas-filled tank with respect to pressure is the change of weight of stored gas per unit change of pressure.

Type Of Capacity	Unit
Thermal	Btu
Pressure	Cubic foot (of gas, standard conditions)
Liquid level	Cubic foot, pound
Electrical	Coulomb
It may be noted that $\frac{\text{Capacity}}{\text{Throughput}}$ = Retention Time	



LIQUID VOLUME CAPACITY vs VOLUME CAPACITANCE

Type Of Capacitance	Unit
Thermal	Btu / Deg
Volume	Cu ft / Ft
Weight	Lb / Ft
Electrical	Coulomb / Volt = Farad

Type Of Resistance	Unit
Thermal	$\frac{\text{Deg}}{\text{Btu / Hr}}$
Fluid	$\frac{\text{Psi}}{\text{Cu ft / Min}}$
Electrical	$\frac{\text{Volts}}{\text{Coulombs / Sec}}$ = Ohms

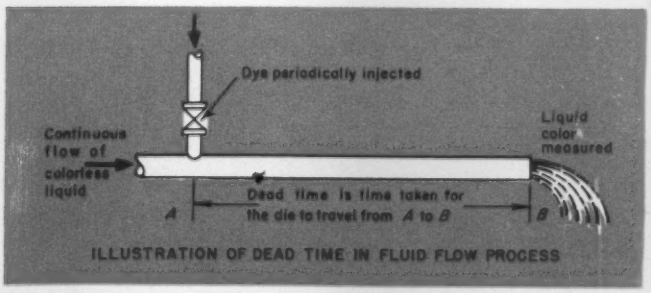

Dye periodically injected
Continuous flow of colorless liquid
Liquid color measured
Dead time is time taken for the die to travel from A to B
A
B

ILLUSTRATION OF DEAD TIME IN FLUID FLOW PROCESS

203. RESISTANCE is opposition to flow. It is measured in units of potential change required to produce unit change in flow.

204. DEAD TIME is any definite delay between two related actions. It is measured in units of time.

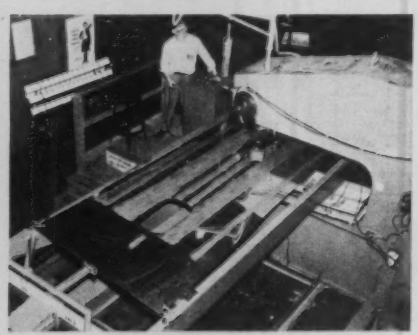
AUTOMATION NEWS

Perforated Film Control

FILM-CONTROLLED riveting machine now in operation at Convair's San Diego division has greatly reduced production time of present work applications. Developed by Convair's tool project section in conjunction with General Riveters Inc., the machine is a five-channel film-index control system. With this unit, five times as many automatic operations can be accomplished as compared with photoelectric indexing systems used previously.

Ordinary 35-mm motion picture film is perforated by the indexing device on the first setup. Specially designed clutches maintain even tension in the film as it unwinds while mechanical feelers sense the punched holes in the film and relay the information to the drilling and riveting head. Three films are used to control the operations; a large spool controls the longitudinal run and cues two others positioned at opposite ends of the work bed, which in turn control the transverse run.

Capable of tightly clamping work pieces, the machine also drills, countersinks, selects the proper rivet, inserts the rivet and sets it all from one starting signal. The film-controlled Drivmatic eliminates hand riveting operations of pilot drilling, reaming, disassembly and deburring, reassembling, and hand loading of rivets.

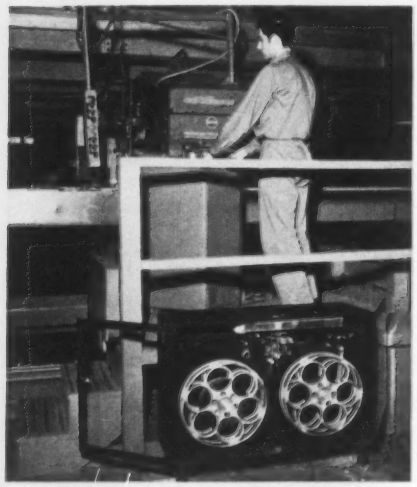


THIS FILM-CONTROLLED automatic riveter was developed by Convair's tool project engineering section San Diego division, in conjunction with General Riveters, Inc., Buffalo, N. Y. The automatic machine is shown drilling and riveting T-29 Air Force Flying Classroom wing panels. Although handling relatively flat panels, the Drivmatic can be set to handle contoured assemblies.

Computer Liaison

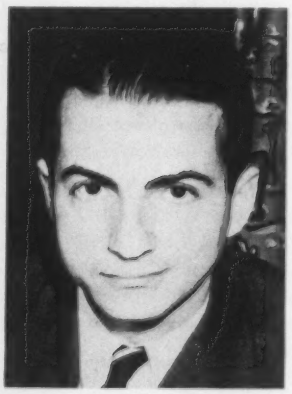
APPOINTED computer consultant by Burroughs Corp., Electronic Instruments Division, as part of the division's plan to expand to industry the services of its giant electronic computer, **Dr. I. Edward Block** will serve as technical liaison to customers who rent the services of Burroughs' unitized digital computer. He will analyze the complex mathematics of customer problems in design, analysis, and data correlation, adapting each problem in turn to high-speed solution by the automatic computer.

Block also will establish a computer training course planned by Burroughs for scientists and engineers from firms who make use of the UDEC computer. For the past three years, services of Burroughs' computer have been rented to many major industrial firms in greater Philadelphia to solve, in a matter of hours or days, problems that would take months or years of human or mechanical computation.



KEY ELEMENT of the automatic riveter in Convair's San Diego division is this spool of perforated 35 mm film which controls lateral feed. Taking its cue from the punched film, the Drivmatic drills, countersinks, selects, inserts and bucks the rivet. This machine is designed for use with a triple hopper which gives a choice of three different rivets.

In 1951 Dr. Block and several colleagues founded the Society for Industrial and Applied Mathematics to help bridge the gap between pure mathematics and applied industrial research and development. The society furthers application of advanced mathematical techniques to practical industrial problems and other scientific endeavors.



Block is now secretary of SIAM and an editor of the society's quarterly journal.

After graduating from Germantown High School in 1941, Block Studied physics at Haverford College, receiving his bachelors degree in 1944. He received his masters degree in mathematics from Harvard University in 1947, and in 1952 his doctorate in mathematics.

He is a member of the American

Mathematical Society, the Mathematical Association of America, the Institute of Radio Engineers, and Sigma Xi.

Instrument For Process Industries

SIGNIFICANT ADVANCE in the 35-year history of mass spectrometry is a new, mobile process monitoring and control type mass spectrometer announced at the Second Annual Meeting of the American Society for Testing Material's committee on mass spectrometry in New Orleans. The latest contribution of western electronics research to industrial progress will furnish the petroleum, chemical, and petrochemical industries with a highly sensitive portable tool for making high speed and accurate analyses of gaseous and light liquid mixtures utilizing cycloidal focusing. Details were described to the ASTM audience in a technical paper presented by **Dr. Charles F. Robinson,** staff physicist of Consolidated Engineering Corp.

Diamonds on the Conveyor Belt

A TWO-MILE CONVEYOR system, longest on the continent of Africa, will soon be installed in the fabulous Williamson diamond mine at Tanganyika, East Africa, to help speed production of diamond ore. The conveyor system will carry diamond ore at the rate of 300 tons an hour from the mouth of the mine to a new processing plant currently under construction, where diamonds and waste will be separated.

When the new plant and conveyor system are put into operation, it is estimated that handling of diamond ore will be increased four-fold over present capacity. The conveyor system will replace a fleet of 15-ton trucks which frequently bog down in mud and cause serious interruptions in production.

Located on a desolate plain famous for big-game hunting, the diamond deposit is said to be potentially the richest the world has ever known. It was discovered in 1940 by Dr. John Thorburn Williamson, former Canadian geologist who has spent years prospecting for African gems. Value of current production has been estimated at $24 million a year, about 12 per cent of the world total.

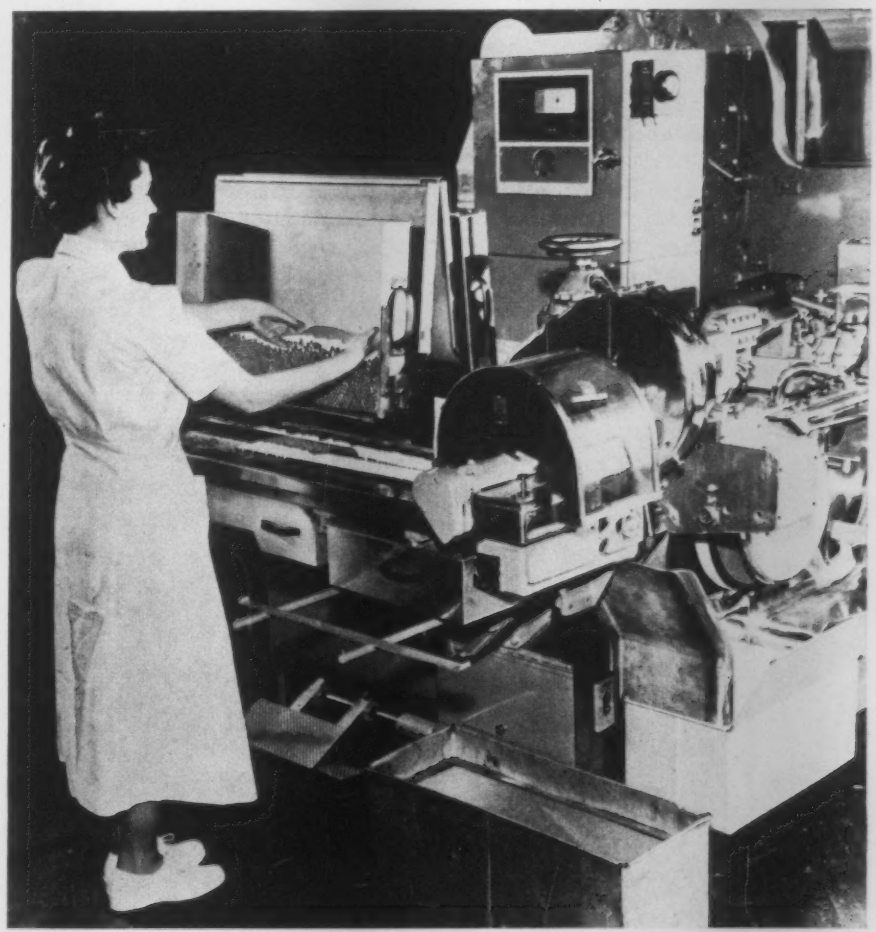
The conveyor system was designed by engineers in the Hewitt-Robins subsidiary, Robins Conveyors (S.A.) Ltd., at Johannesburg, South Africa, and the machinery is being manufactured in the Johannesburg plant.

Coffee Beans Too

COMPLETELY MECHANICAL differential weight integrator automatically and continuously records the product of varying conveyor belt speeds and momentary weight per foot of belt passing over the scale suspension. This totally enclosed unit is now in use for conveying, weighing, and regulating flow of coffee beans from storage bins to grinder in a large instant coffee processing plant.

Maximum bean size is ¾-in., beans weigh 20 lb per cu ft; conveyor belt is 18-in. wide, handling approximately 4,000 lb per hour.

Designed and manufactured by Dwight Lloyd, Inc., Transportofeeders can be built to convey and weigh a wide range of materials. Instrumentation can be incorporated to control other integrated feeding equipment, to stop the entire



CIGARETTE MANUFACTURERS may control their cigarette-making machinery automatically and assure a more uniform product by an isotope employed to regulate density. Each package of cigarettes will be more uniform since average cigarette weights are confined to an extremely narrow range. Main benefit to the smoker lies in the constant product uniformity eliminating air pockets in a cigarette and assuring an even burn. Four main functional units make up the attachment including a radio-isotope equipped beta gage which measures the cigarette density, a proportional control which governs feed rate of tobacco to the cigarette-making machine in response to the beta gage signal, the dielectric detector which measures the deviation from correct average weight of each individual cigarette, and the rejector which eliminates off-weight cigarettes. American Machine & Foundry Co., manufacturer of tobacco-processing equipment, developed and produces the "microfeed."

operation at a preset total weight or on failure of material supply.

Ceramic Relay Less Costly

A NEW INVENTION marketed recently after several years of research and development by The Mullenbach Electrical Mfg. Co., is the first application of the principle known as electrostriction to an electric relay. In place of the conventional electromagnetic system, the relay is actuated by a ceramic element which contracts upon being electrically charged and expands upon being discharged. This ceramic also has the characteristic of a capacitor since it will hold an electric charge. The device, called a Capaswitch, operates on extremely low power such as may be supplied by a photoelectric tube without intermediate amplification. The energy required is one-half a milliwatt second, contacts are rated one ampere at 110 volts ac.

Because of its low energy requirements, the Capaswitch is expected to replace other types of relays and to obviate need for far more costly and elaborate devices, as well as reduce the amount of waste heat generated. Ideally suited for use in electronic computing equipment, electronic plate circuits, and in closed circuit detector systems, expected uses are that of a component in regulating and control systems for air conditioning equipment, burglar and fire alarms, tele-communications equipment, and servo mechanisms for industrial machinery.

The Worthington Corp., now owners of The Mullenbach Co., state that the Mullenbach plant in Los Angeles will continue to be used as a pilot plant for the manufacture of the Capaswitch while larger facilities are being prepared for increased production.

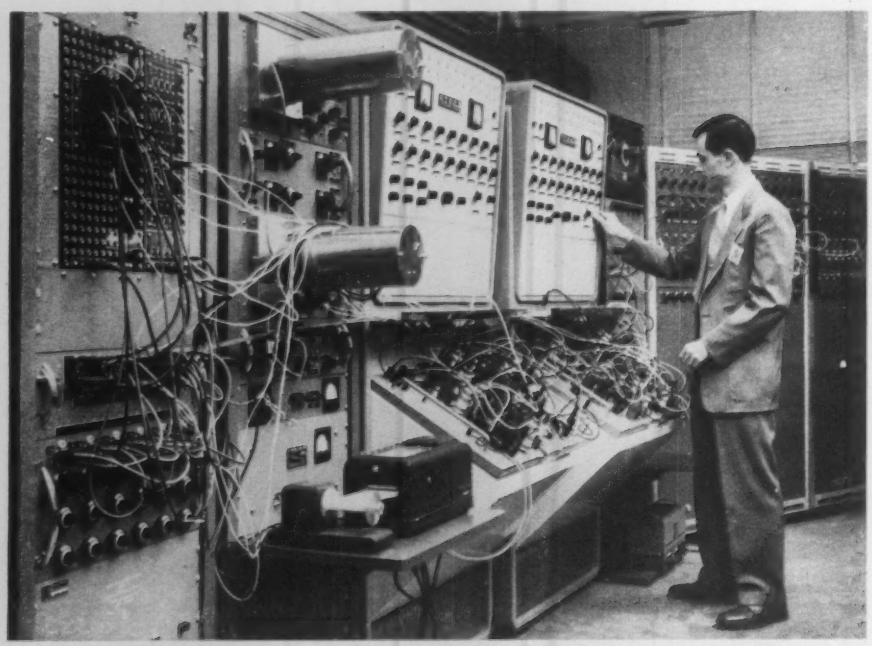
Automatic Elevator Development

OWNERS AND MANAGERS of office buildings throughout the country witnessed the first public demonstration of latest electronic development for operatorless elevators at the annual convention of the National Association of Building Owners and Managers in Denver recently. Known as the Westinghouse "traffic sentinel," the device automatically tells elevator doors when to close by means of an invisible light beam which counts incoming and outgoing elevator traffic at each stop.

Operating as an electronic "doorman," the new development makes it possible for groups of completely automatic elevators to surpass attendant-driven systems in operating efficiency. It operates by projecting an infrared light ray across the entrance of an elevator car a foot above the floor. The ray automatically adjusts door closing time according to the number of people moving in or out of the car. When traffic is lighter, the door stays open a shorter time.

Interruption of the light beam has a different effect on door closing time, depending on whether the car is stopping to discharge or to receive passengers. When a rider is admitted, break in the beam cuts down the predetermined door closing time from the regular five-second interval to two seconds. When a rider leaves, the interval was cut to one-half second. All time decisions are made automatically.

For maximum safety and efficiency, the model car at the convention combined "traffic sentinel" with Westinghouse "Saf-T-Edge" doors which reverse at the slightest pressure. If anyone lounged in the doorway of the model cab, a recorded message urged: "Please release the doors." If this advice was ignored and the beam remained interrupted for as long as 15 seconds, another message cautioned: "Keep clear . . . doors are closing." The Saf-T-Edge then closed gently but firmly, nudging him out of the way.



NEW ELECTRONIC analog computing machine is helping scientists at Battelle Institute solve complicated problems pertaining to vibration, dynamics, and suspension in automotive, home appliance, and industrial equipment fields. Developed by Battelle electrical engineers as a special research tool, the computer is able to solve equations pertaining to systems which contain nonlinearities. These functions occur widely in nature but cannot be analyzed easily by mathematical means, yet improvements in many products may require their analysis.

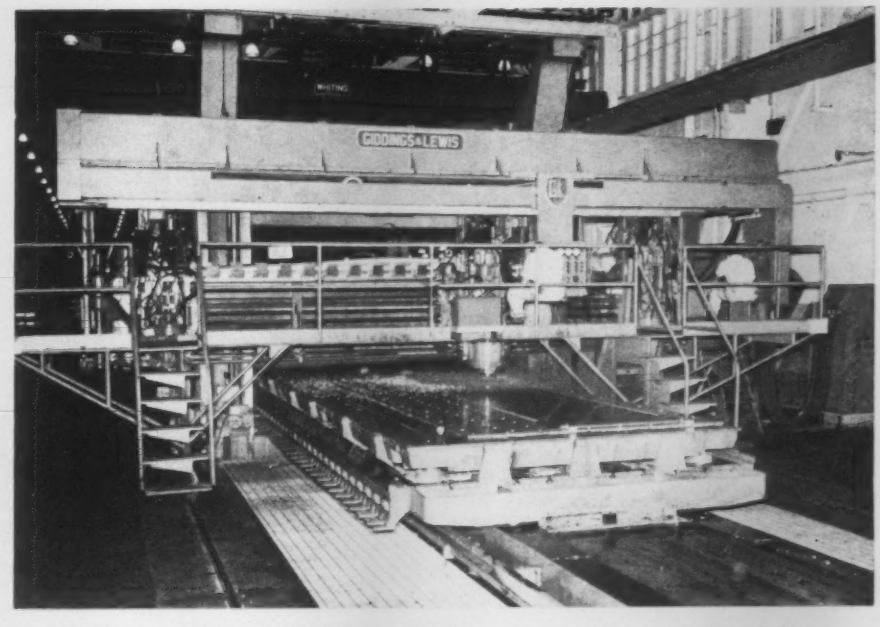
Change Training Director

SUCCEEDING **Mr. Malcolm B. Hall** who recently completed 40 years of service with The Foxboro Co., **Mr. W. H. T. Furry** has been named director of the training and educational division of the Foxboro Co.

Widely experienced in instrument education work, Mr. Furry has taught courses for Pennsylvania State College in cooperation with the Philadelphia section of

the Instrument Society of America and also served as chairman of the educational committee of the Philadelphia section of ISA. Prior to joining Foxboro in 1952, he was instrument training coordinator at the Atlantic Refining Co. in Philadelphia.

Mr. Hall, who joined the company in 1909, has been director of training since 1942. Under his leadership the school originated specialized courses in advanced electronics, special training in textile, chemical, food, municipal and pulp and paper instrumentation, as well as professional forums. More than acting in an advisory capacity at the school, Mr. Hall will continue his series of lectures, including his explanations of automatic control—a field with which he has been associated since the early development of modern process instrumentation.



WORLD'S LARGEST combination spar and skin milling machine designed to fashion supersonic aircraft has begun operation at the El Segundo Div. of Douglas Aircraft Co. The intricate mill, weighing 25 tons, can machine entire sections of an airplane from thick aluminum plate. Built to Douglas specifications, it has been under construction for two years. A trend is developing toward fabrication of large self-reinforcing sections rather than by piecing hundreds of riveted parts. Milling of a typical wing section from a piece of 2-inch plate, 8-ft long by 4-ft wide reduced parts from 29 to 1 and eliminated 1300 rivets. The versatile machine can carve out hundreds of parts into self-strengthening shapes and finish them quicker than by conventional methods. Rise and fall of cutting heads are actuated hydraulically from templates. Controls were furnished entirely by GE.

International Atomic Energy Discussions

OFFICIAL representatives from 17 foreign nations have been invited to address The National Industrial Conference Board's Third Annual Conference on Atomic Energy in Industry to be held in New York, in October. In keeping with President Eisenhower's policy of encouraging international cooperation, the Conference Board is inviting heads of atomic energy programs of Argentina, Australia, Belgium, Brazil, Canada, Denmark, France, Great Britain, India, Italy, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland, and the Union of South Africa to address the sessions.

Conference sessions will include discussions of the current outlook on atomic power costs, uses of atomic by-products in medicine, uses of radio-isotopes in process industries, how to get know-how in atomic energy, public safety and atomic power reactors, economic factors in locating atomic reactors, legal problems of peacetime atomic developments, uses of radio-isotopes in agriculture, atomic energy planning by American and Canadian companies, uses of radio-isotopes in metal and metal-fabricating industries, peacetime utilization of atomic fission products, and research and low-power reactors and their uses. Evening and luncheon sessions of the conference will be addressed by individuals prominent in industrial applications of atomic energy both here and abroad.

New VPs

DIRECTORS of the McKay Machine Co., Youngstown, O., have named **Ambrose J. Wardle, Jr.** vice president in charge of sales and **Carl J. Honen,** vice president in charge of advertising and sales promotion. Both previously were assistants to the president. **Mr. R. J. Miller,** was also advanced from vice chairman and vice president, to vice chairman and first vice president.

Photocell Without Amplifier

LOW COST and extremely small cadmium sulphide crystal photocells introduced by the Standard Piezo Co., are capable of operating relays directly without an amplifier.

Standard types as small as ¼-in. diameter by ¼-in. deep, exclusive of leads, deliver from 2 to 5 milliamperes when exposed to light of from 50 to 100 foot-candles intensity with approximately 100 volts applied across cell and load. Therefore, on applications where a light source of good intensity can be used, no amplifier is needed. Even where an amplifier becomes necessary on other applications, materially lower cost and smaller size of the photocell assure a substantial saving for the assembly.

These photocells show usable resistance change with light intensities as low as 0.0001 foot-candles. Speed of response, usual deficiency of photo conductive devices, is in the order of 0.01 second at 50 foot candles—sufficient to operate the fastest relay in counting or activating applications.

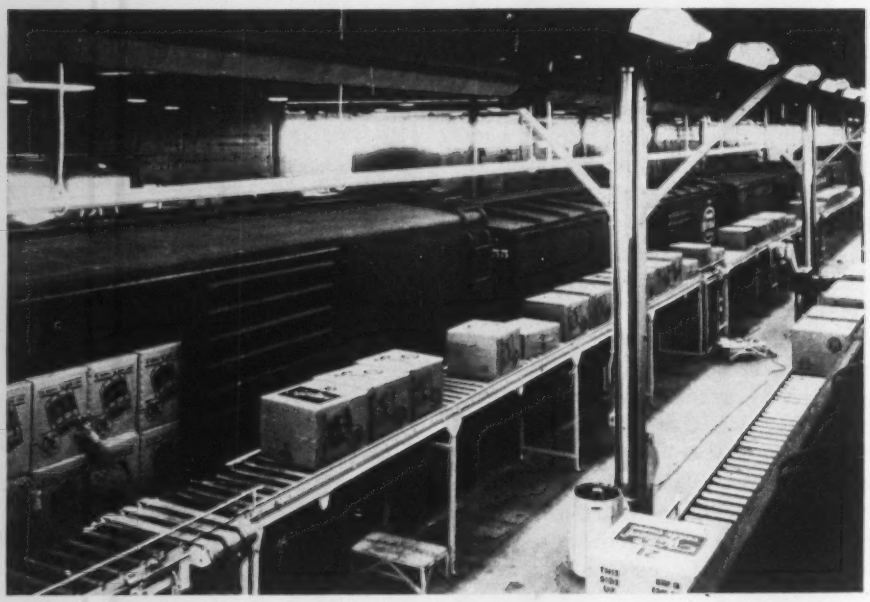
Photocells respond to visible light, ultra violet, x-rays, and nuclear radiations. This wide response plus small size of the light-sensitive element, 2 square millimeters, make the units well suited for x-ray detectors, densitometers, and other measuring applications where the

sensitive element must be as small as possible to insure accuracy.

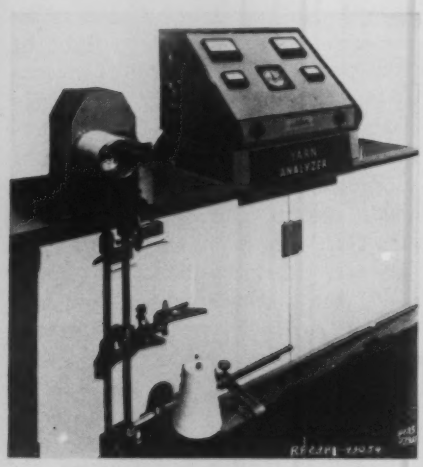
Success in Co-operative Effort

AUTOMATIC MEANS to divert various products from a trunk line conveyor to preselected branch lines have been developed in the materials handling field. After several years of trial and error experimentation, Scott Paper Co. engineers with assistance from the Alvey Conveyor Mfg. Co., the General Electric Co., Hires Castner and Harris, and the Wilkie Co., have designed and now have in successful operation a system of conveyors which permits the automatic dispatching of products to 18 freight car, 5 truck, and 2 warehouse locations.

This outstanding new development is an excellent example of what can be accomplished by the cooperative effort of a number of companies, each specialists in their field, which is so characteristic of American industry. Advantages are obvious to any operator of a multiproduct warehousing, order filling and shipping operation. As plants grow and warehouses are, of necessity, at some distance from the production lines, this type of equipment will permit a single transportation conveyor for all products without the expensive manual sorting operation in the warehouse that has heretofore been required.



CARTONS traveling along the trunk line conveyor signal an electric eye at each branch conveyor junction, left foreground. If the marking on a given carton corresponds to the setting of that particular transfer mechanism, an electric circuit is set up which operates a diverting device to switch the carton to the predetermined car, truck, or warehouse location. Mobile telescopic conveyors carry the cartons into the extreme end of cars and trucks, thus minimizing handling all along the way.



HIGH-SPEED yarn analyzer that measures variations in yarn evenness was shown at a recent American Textile Machinery Exhibition. Developed after study of textile industry needs, the analyzer adjusts automatically to any count of yarn within range of the electrode used, retains analyses on memory dials until the winding guide is reset, and computes measurements taken to read in percentage variation.

Developed by Fieden Instrument Div. of Robertshaw-Fulton Controls Co., the analyzer offers textile manufacturers the opportunity to gather essential information rapidly on materials and quality control data.

Sales Area Changes

APPOINTMENT of two new branch managers, **Merritt Eusey** and **Robert S. Warnick** and creation of a new district managership at Greensboro, N. C., have been announced by Minneapolis-Honeywell Regulator Co.

Mr. Eusey, former head of the company's Baltimore branch, has been named to head the Pittsburgh office, succeeding **Ray Weikel** who has assumed a supervisory position with Honeywell's Industrial Division in Philadelphia. Warnick, formerly a supervisory commercial salesman in the Philadelphia office, has succeeded Eusey as branch manager in Baltimore.

Donald H. Hannasch has been appointed to the newly created position of district manager at Greensboro. He has been resident salesman at Rochester, Minn.

Data Handling For Mails

REPRODUCTION by combination of optics and electronics has been utilized in printing addresses, bills, checks, notices, and sales promotion material. Electrical pulses, generated by a photo electric scanner and amplified electronically, actuate a series of printing vibrators which reproduce source data in facsimile on various paper records. Addressograph-Multigraph's electronic printers employ as source records ordinary unit cards on which repetitive information has been typewritten between rows of punched holes. Conventional A-M plates are not used.

Leading publishers have machines in operation or on order for paper work connected with securing, recording, fulfilling, and renewing subscriptions. New developments are pointed to extension of use to include insurance companies, public utilities, financial institutions, industry and government.

GRADUATE COURSES in subjects dealing with automation are being offered during the present academic year at Case Institute of Technology during the afternoon and evening sessions.

Reorganization in Buffalo

TO REPLACE the former engineering department at the company's Buffalo plant, American Machine & Foundry Co. has established two new engineering departments, Advanced Development Engineering and Buffalo Product Engineering.

Robert L. Holloway, formerly chief engineer of the Buffalo plant, has been appointed chief engineer of the Advanced Engineering Department. Associated with AMF since September, 1946, he was at one time manager of the Buffalo engineering department's special products and development section.

Chief engineer of Buffalo Product Engineering Department is **Herbert E. Oles,** formerly section manager of product engineering of the former engineering department. In addition to this position, he was also project engineer for Navy contracts at the Buffalo plant.

One of the larger of AMF's plants, the Buffalo production center manufactures bread-wrapping machinery, pretzel-tying machines, the AMF automatic pinspotter, Radaray, bowling automatic foul detector, and defense equipment.

Cemented Carbides for Automatics

WORKING JOINTLY in a continuing development program to learn how to make effective use of cemented carbides on multiple spindle bar automatics, engineers of Cone Automatic Machine Co., and Carboloy Department of General Electric Co. indicate that automatic users can expect a greater return on capital investment through production increases on machines, as much as 50 to 100 per cent. Benefitting from the joint efforts of the two organizations are users of automatic machines. In reviewing the obstacles that had to be surmounted before carbides could be successfully used on multiple spindle automatics, Cone and Carboloy agreed on a program that would set up conditions simulating those in the field as near as possible.

As most multiple spindle setups are individualized it was agreed to seek actual jobs for development that made use of the commonly known tools, and at the same time jobs that were representative of volume production by the machine. For example, one machine was tooled up to make use of end and side tools that are familiar to all users of automatics. Another was set up to handle tubing in the production of ball bearing inner races. A third machine was set up to handle the type of threading that can be accomplished with carbide tipped die head chasers.

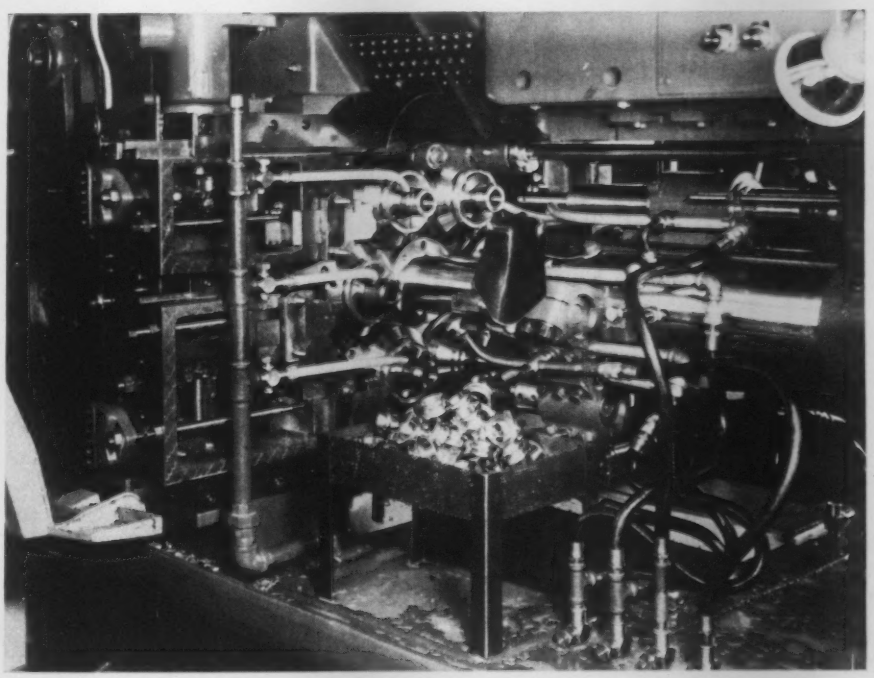
In all three jobs, coolants played an important role. The engineering team found that by sealing off bearing and spindles of the automatics, water soluble coolants did an effective job of cooling both the machine and cutting tools when machine speeds were increased 10 times.

The trend toward automation and fully automatic equipment to get more production per square foot of floor space has provided extensive opportunity to the multiple bar automatic. Theoretically, with the same tool material on a job equally adaptable to both multiple and single spindle bar automatic, the multiple should out-volume the single in accordance with the number of work spindles involved. To maintain so great a production advantage, Cone believes that multiple spindle bar automatic builders must prepare to provide the user with machines with at least as efficient accommodation of carbide tools as is provided by the single spindle machines.

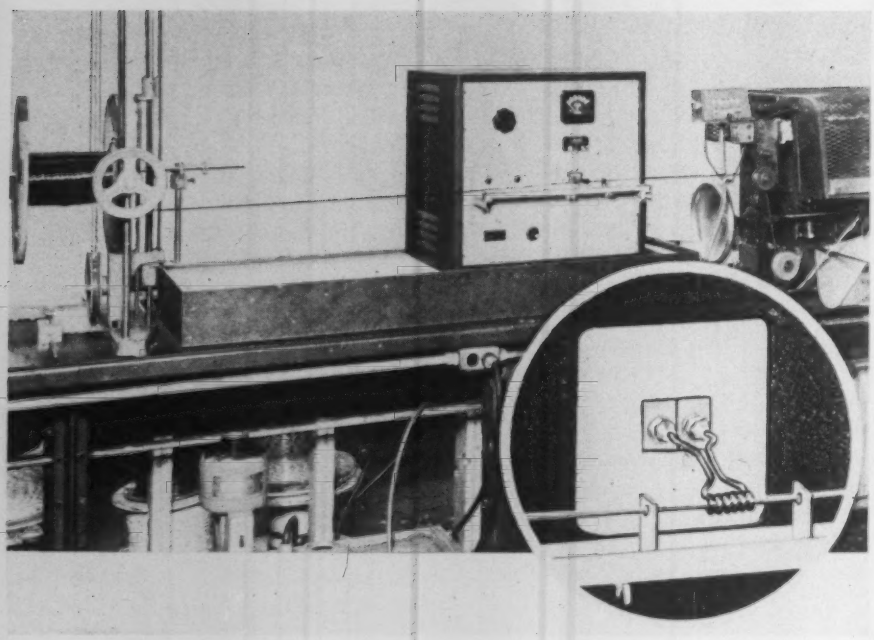
ASME Paper

SUBJECT OF A PAPER to be given at the ASME meeting September 8-10, in Milwaukee is "The Electromagnetic Clutch, Its Operation, Application and Control" by **H. B. Stallings,** sales engineer for electromagnetic clutches, I-T-E Circuit Breaker Co.

Mr. Stallings studied mechanical and electrical engineering at Armour Institute of Technology, and business administration at the University of Pennsylvania. He has been closely associated with engineering and management problems of central power stations, marine, machine tool, iron and steel, rubber and chemical indus-



ONE STANDARD inner bearing race drops through the chute of this 6-spindle automatic machine every 10 seconds. Operations are done with only seven carbide cutting tools, half the number required when using high-speed cutting tools. Tool life for the Carboloy grade 370 cemented carbide was 724 pieces per grind for internal necking, 1270 for butt facing, 1518 for breaking down for cutoff, 1890 for vertical cutoff, 810 for forming, 720 for cutoff, and 1270 for reaming. Work was run at a speed of 519 rpm.



AN INDUCTION HEATING unit to bond together individual strands of multi-strand wire and cable, preventing ends from becoming frayed, eliminates necessity of tin dipping ends after cutting and stripping. The low cost portable unit may effect savings in radio, television, electrical apparatus and appliance manufacture. Wire is fed continuously through the generator load coil while the heating cycle and wire cutter stroke are synchronized. The unit developed by Lepel High Frequency Laboratories, Inc., is also suited for heat treating surgical needles, dental burrs, localized annealing of spring wire and joining wire products.

tries. Known in the machine tool industry, Stallings is a member of American Institute of Electrical Engineers, Association of Iron and Steel Engineers, American Institute of Management, and Engineering Society of Western Pennsylvania.

Cleaning With Sound

A NEW TYPE ultrasonic cleaner for processed parts which saves up to 90 per cent of costs for solvents and more than half the direct labor cost for existing methods of industrial cleaning is going into commercial production. First deliveries of the device, known as the Bendix Aviation Ultrasonic Cleaner, began about August 1. The unit operates with either water-soluble detergents or cleaning solutions and features the low-frequency, magneto-strictive transducer achieving high penetration of ultrasonic energy.

MEETINGS AND EVENTS

Sept. 11-14—

Packaging Machinery Manufacturers Institute. Twenty-second annual meeting to be held at Grove Park Inn, Asheville, N. C. Additional information may be obtained from society headquarters, 342 Madison Ave., New York, 17, N. Y.

Sept. 15-22—

Instrument Society of America. First International Instrument Congress and Exposition will be held at the Commercial Museum, Philadelphia, Pa. P. V. Jones, Jr., ISA, 1319 Allegheny Ave., Pittsburgh 33, Pa., is manager.

Sept. 27-30—

Society of Industrial Packaging and Materials Handling Engineers. Annual exposition to be held at the Coliseum, Chicago, Ill. Additional information may be obtained from society headquarters, 20 West Jackson Blvd., Chicago 4, Ill.

Sept. 28-Oct. 1—

Association of Iron & Steel Engineers. Annual convention and biennial exposition will be held at the Public Auditorium, Cleveland, O. T. J. Ess, 1010 Empire Bldg., Pittsburgh 22, Pa., is manager.

Sept. 29-30—

Symposium on Industrial Electronics. Third Annual Conference to be held at the Mellon Institute of Industrial Research, Pittsburgh, Pa., under the sponsorship of the Professional Group on Industrial Electronics and the Pittsburgh Section of the Institute of Radio Engineers. Additional information may be obtained by writing J. B. Woodford, Jr., Electrical Engineering Dept., Carnegie Institute of Technology, Pittsburgh 13, Pa.

Oct. 4-6—

National Electronics Conference. Tenth annual conference to be held at the Hotel Sherman, Chicago, Ill. Conference under the sponsorship of the American Institute of Electrical Engineers, Illinois Institute of Technology, Institute of Radio Engineers, Northwestern University, University of Illinois, with participation by the Radio Electronics Television Manufacturers Association, Society of Motion Picture and Television Engineers, Purdue University, and University of Wisconsin. R. E. Hornacek, N. E. C., 208 West Washington St., Chicago 6, Ill., is chairman.

Oct. 5-9—

Society of Automotive Engineers. National Aeronautic Meeting, Aircraft Production Forum and Aircraft Engineering Display to be held at the Hotel Statler, Los Angeles, Calif. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18, N. Y.

Oct. 11-15—

American Institute of Electrical Engineers. Fall general meeting to be held at the Morrison Hotel, Chicago, Ill. Additional information may be obtained from H. H. Henline, Secretary, 36 West 46th St., New York 36, N. Y.

Oct. 12-15—

American Chemical Society, Chicago Section. National Chemical exposition to be held at the Coliseum, Chicago, Ill. Additional information may be obtained by writing to society headquarters, 86 Randolph St., Chicago 1, Ill.

SHEFFIELD

AUTOMATION Gages

Assure Fast Accurate Machining

Sheffield Automation Gages are package units, ready-to-use and economically priced, for the control of grinding, boring, drilling, honing, milling and turning operations.

Mounted on machine tools, they measure work part dimensions and space relationships and instantly translate this information into electrical impulses which in turn:

- **Energize signal lights**
- **Actuate solenoid ejection or classification mechanisms**
- **Start and stop the machine tool**
- **Provide feed-back control**
- **Control cutting tool or grinding wheel positioning and compensation, also time cycle.**

A Typical Application

Here the bore of transmission pinions is being honed and gaged automatically.

If the actual bore size, after honing, is within .0001" of either tolerance limit, white warning lights flash on.

If either tolerance is exceeded, a red or green signal flashes and the faulty part is automatically ejected.

When a predetermined number of rejects pass through in succession the machine is automatically stopped.

The actual size of each bore, as it is gaged can be read on a conveniently located air gage dial as built into the machine tool pneumatic circuit.

The Sheffield Corporation, Dayton 1, Ohio, U.S.A.

MASTER CRAFTSMAN SHEFFIELD HEADQUARTERS

SHEFFIELD

Sheffield AUTOMATION ENGINEERS will gladly consult with you about automatizing your production.

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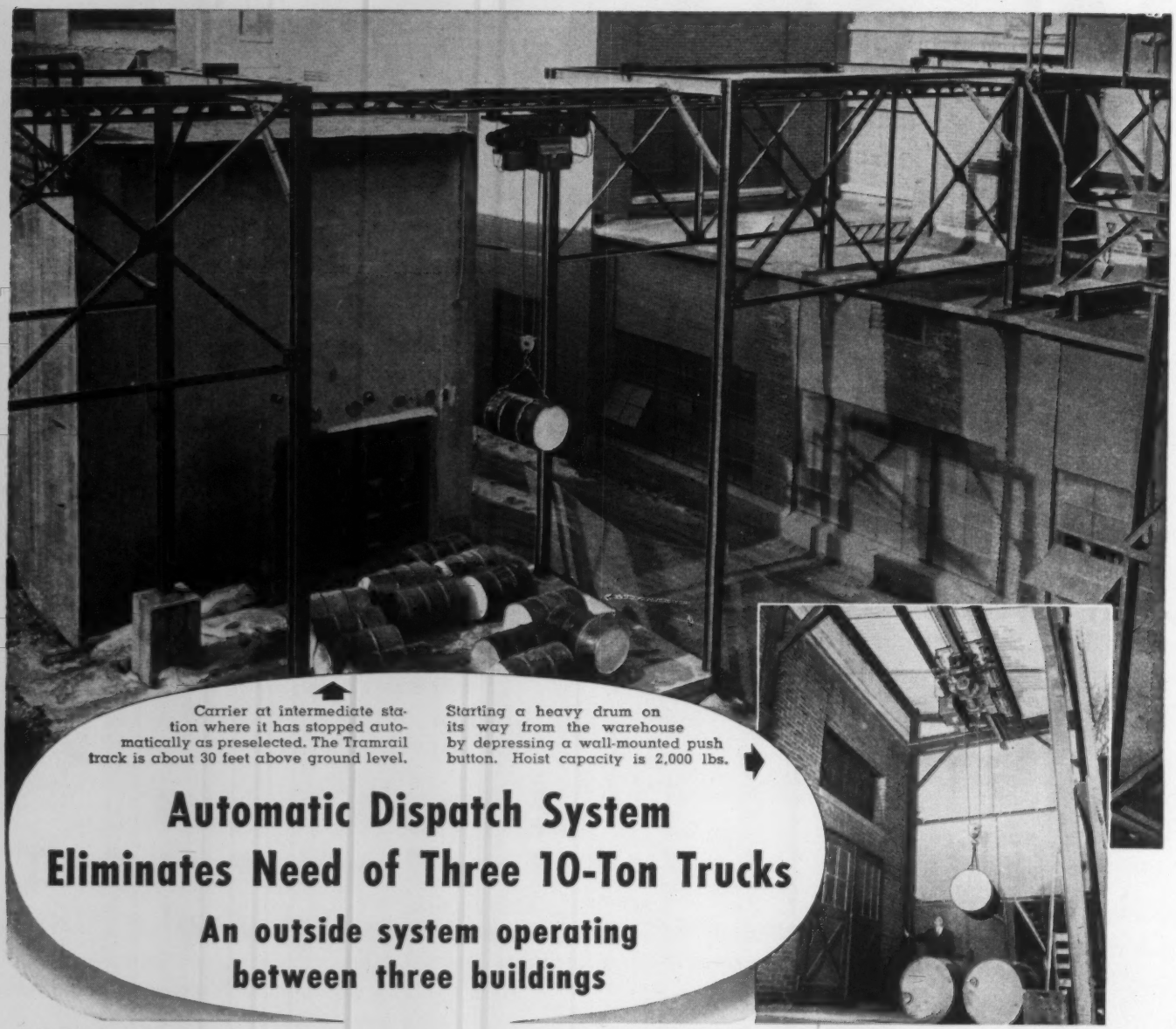

Carrier at intermediate station where it has stopped automatically as preselected. The Tramrail track is about 30 feet above ground level.

Starting a heavy drum on its way from the warehouse by depressing a wall-mounted push button. Hoist capacity is 2,000 lbs.

Automatic Dispatch System Eliminates Need of Three 10-Ton Trucks

An outside system operating between three buildings

Not only was the need of two 10-ton trucks obviated by a Cleveland Tramrail automatic system at the Mica Insulator Company, Schenectady, N. Y., but the purchase of a third truck was made unnecessary. While the trucks had to travel over a circuitous route, only a short, straight Tramrail track is required for the overhead system.

Many man-hours of trucking and handling time are saved because materials dispatched over the automatic Tramrail system can be handled by production workers along with their regular jobs. A great amount of handling on an elevator has also been eliminated and better elevator service is available for other purposes.

The system has been found particularly helpful during night shifts when an extra drum of varnish or roll of cloth is sometimes needed. Formerly trucks were never available for night hauling. The Tramrail equipment paid for itself out of savings it created in a short period.

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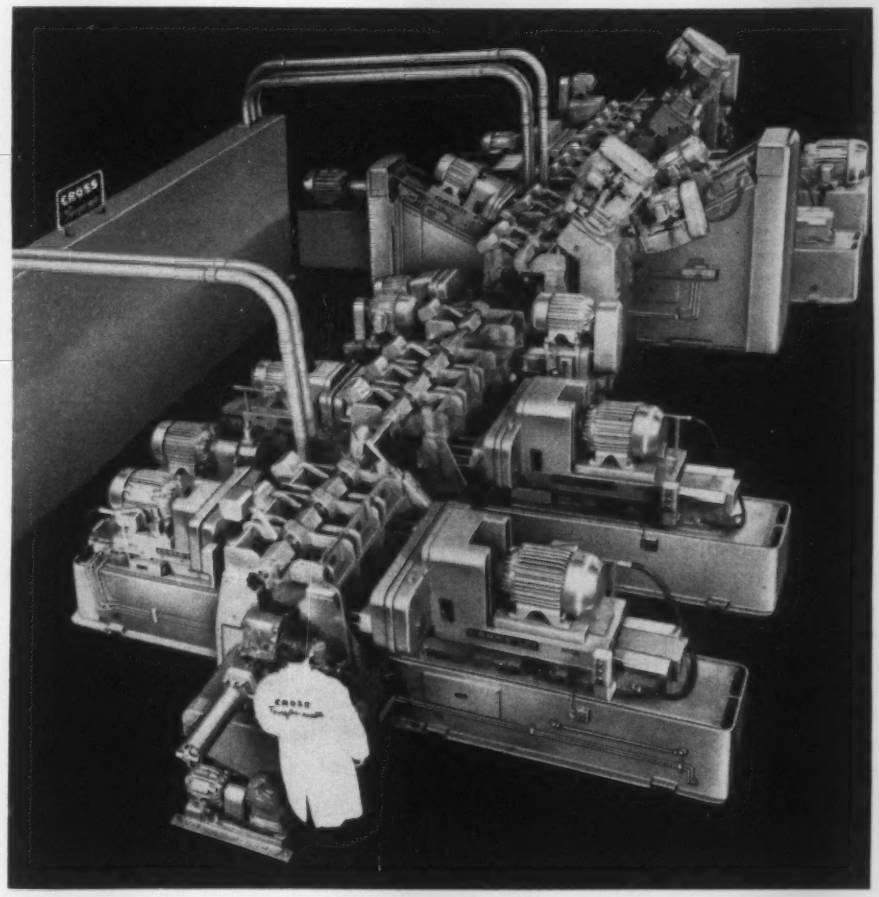
CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

AUTOMATION NEW EQUIPMENT



AUTOMATIC TRANSMISSION HOUSINGS

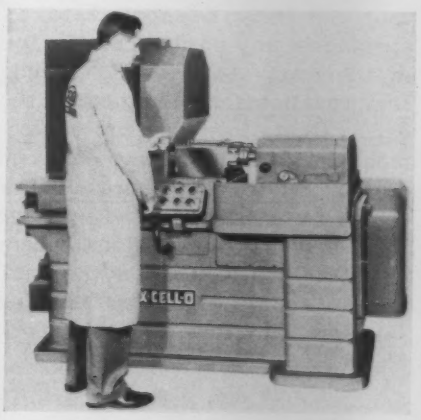
A new Transfer-matic machine will process 100 automatic transmission housings an hour at 100 per cent efficiency. The unit comprises 29 stations and performs six operations—drilling, chamfering, end milling, counterboring, reaming and tapping the sides, ends and tops of the housings. Special feature is a 90-degree indexing of the part in station 14 for drilling sides and top.

Pre-set tools are used and a special control unit with Toolometers programs the tool changes. All standard and special parts are interchangeable to facilitate easy maintenance. Housings are automatically transferred from station to station. The unit contains an individual lead screw feed for tapping, hardened and ground ways and gravity operated cam clamping. Hydraulic feed, rapid traverse and a built-in chip conveyor are also featured. **Cross Co.**, 3250 Bellevue, Detroit 7, Mich.

Circle No. **1** *on Reply Card*

PRECISION BORING

Cam operated precision boring machine is designed for finishing work such as contouring, boring, turning, facing and grooving. Cam followers impart rise and fall of the cams directly to machine table and cross slide, eliminating all need for levers. Machine is built to accommodate parts which can be rotated on spindles while nonrotating tools are supported on cross slide. Forms being reproduced over and over again within close tolerances can be inspected by checking only one dimension since accuracy and relationship of other dimensions are determined by the cams. Contour form is obtained by longitudinal movement of table coordinated with lateral movement of cross slide. Table carries spindles and their drive equipment, is operated in rapid traverse by a pneumatic cylinder cushioned by oil. Feed portion of table stroke is actuated by a cam opposed by an air cylinder, as are all cross slide movements. Whole cam assembly is hinged to swing out of its compartment for changing the cams. Hardened and ground cams are engaged by felt



oil wicks to maintain a film of lubricant. Automatic power lubricating system delivers oil to the ways during each work cycle. A large, sloping chip chute is cast integral with the base of the machine in such a way as to prevent any chips or coolant from entering base. **Ex-Cell-O Corp.**, 1200 Oakman Blvd., Detroit 32, Mich.

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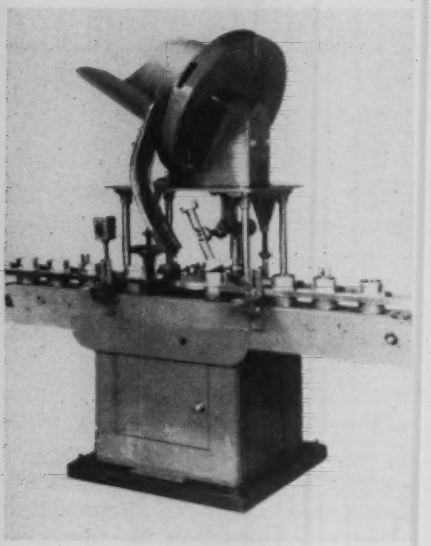
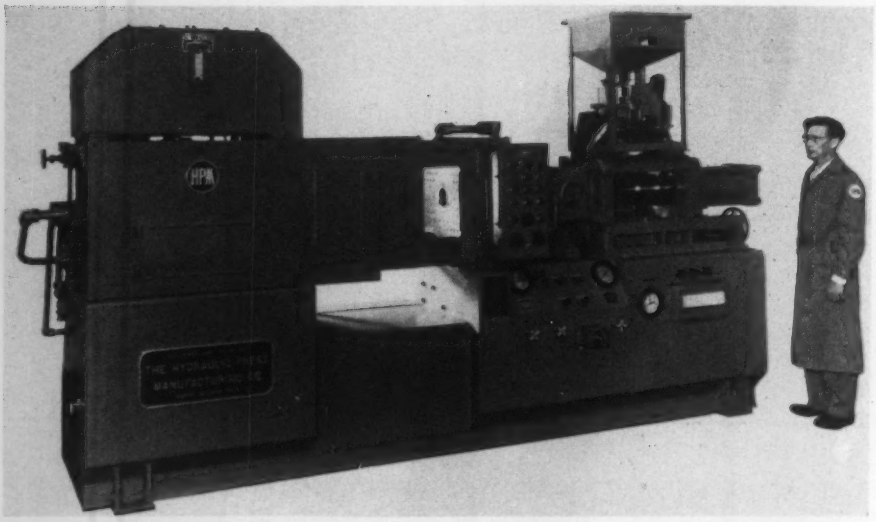


AUTOMATIC LID SEALER

Inner seals, plugs, friction lids, or any type metal seals are applied automatically to metal and fibre cans of all shapes by an automatic capping machine. Lids are applied while can is in motion to eliminate danger of splashing and for greater output. A hopper automatically feeds lids or seals into a chute where a rotating head picks up the seal and applies it to can as it moves into position. Rotating head is equipped with magnetic fingers, and both head and fingers are fully adjustable so that lids may be applied to an opening in any position on the top of the can. Adjustments include compensation for variations in the cans. Chute has a special escapement device which allows only one seal or lid to be withdrawn at a time. A spinning head can be furnished for applications where seals are rolled in under the neck of the spout. **Tite-Cap Machine Co., Inc.**, 59A Rose St., New York 38, N. Y.

Circle No. 3 on Reply Card



PLASTICS INJECTION MOLDING MACHINE

A fully automatic 6 to 8 oz capacity injection molding machine is designed for thin walled containers as used in packaging dairy products, for pharmaceutical containers, toys, lighting fixtures, and small electronic parts. Mold mounting space can accommodate family molds as used in the toy industry. One attendant can operate from 4 to 6 machines, and each machine can cycle up to 400 times an hour depending upon design of molded part. Straight-line, hydraulic mold clamp has fast closing and opening speeds and automatic slowdown prior to mold contact, at mold breakaway, and during ejection of molded parts. No compensating adjustments are necessary for different mold thicknesses. Injection unit is mounted on ways and actuated by a single hydraulic cylinder. Hydraulically actuated, positive sprue break can be used at discretion of operator. Small, high pressure axial piston pump in the hydraulic circuit develops maximum clamp pressure, while a high capacity, double-vane pump serves both clamp and injection rams. Plasticizing chamber has three pyrometer controlled heat zones. Quick changing ram spacer permits use of thin molds without bolsters, and an opening beneath the mold mounting area provides space for chutes or unloading facilities for automatic molding operations. Low pressure mold protection prevents high pressures from developing in the mold cavities if a part has not been ejected on the previous cycle. Compensating material weigh feeder is optional. Overhead oil tank prevents contamination of oil. Front limit switch panel permits all stroke adjustments to be made at front of machine, and all hydraulic components are accessible. Maximum mold capacity is 150 tons, and maximum mounting space is 15 x 20½-in. Machine is operated by a 20-hp motor. **Hydraulic Press Mfg. Co.**, Mount Gilead, Ohio.

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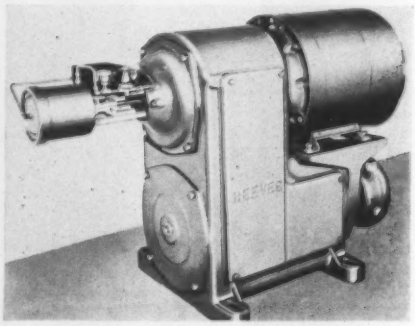

SPEED CONTROL

An autopneumatic control is used in conjunction with the Reeves Vari-Speed Motodrive to continually correct its operating speed according to changes in material and/or energy variations of a process. Control can compensate for changes in temperature, liquid level, pressure, heat, flow, color, velocity, peripheral speed, and tension. Control can be used

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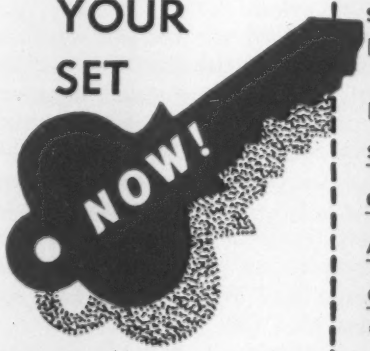

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with Motodrives of all sizes of fractional and integral hp capacities. Unit consists of a valve positioner and a pneumatic piston which connects to the speed shifting mechanism. Any change in piston's position changes the output speed. Piston's position is determined by the valve positioner which is operated from a 3 to 15 psi signal sent from any instrument control. Any minute change in air pressure is transmitted and actuates rpm change on Motodrive's output shaft. Autopneumatic control operates through a cam control which matches the natural curve characteristics of the Motodrive and compensates for any minute variation. **Reeves Pulley Co.**, Columbus, Ind.

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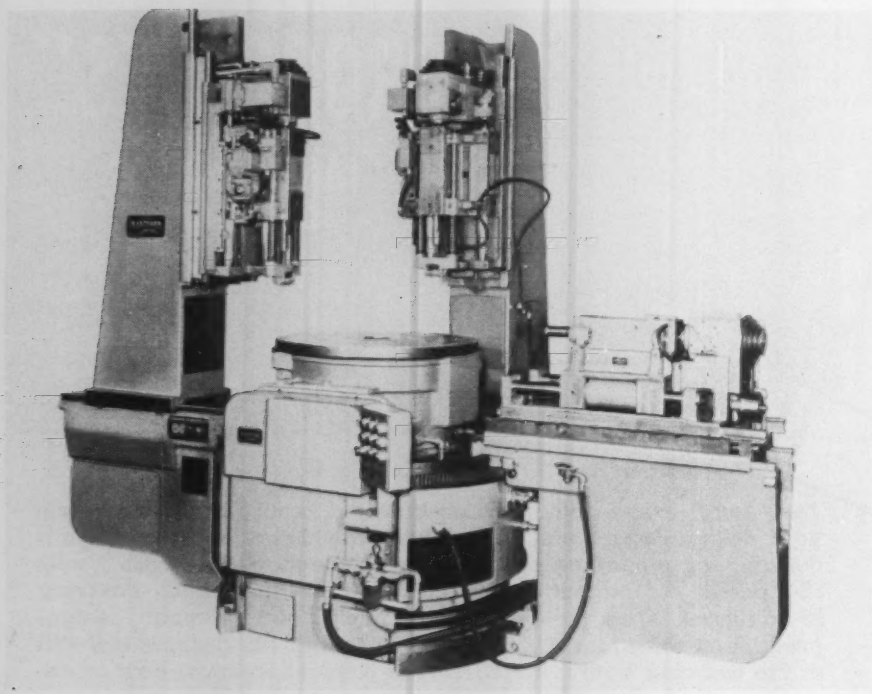

MULTIPURPOSE DRILLING MACHINE

A fully automatic drilling machine is designed as a standardized basic machine accurate enough for aircraft parts and rigid enough to hold tolerances in heavy work. As many as four drilling and tapping units can be accommodated, and all are quickly adjustable radially, vertically, and circumferentially. Easily changed cams for program control permit quick conversion to meet engineering changes. Air hydraulic heads drill up to ¾-in. holes in mild steel, and ½-in. in stainless, with interchangeable index plates for equal or unequal hole patterns. Spindle speeds run from 180 to 6700 rpm, feed range from ½ to 40 in. per minute. Capacity ranges from 30-in. diameter work with 8-in. diameter bolt circle to 87-in. diameter work with 65-in. bolt circle diameter. Special index setups allow up to 192 indexes. **Hartford Special Machinery Co.**, 287 Homestead Ave., Hartford 12, Conn.

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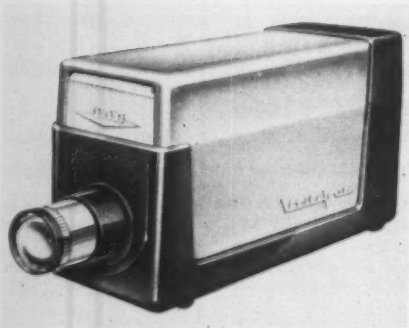

INDUSTRIAL TELEVISION

"UtiliVue" is a new closed circuit television which can be tuned to any channel from 2 to 6 when used with either a Video monitor or a standard receiver. Uniform picture quality and operating stability are assured. All controls and power supply, as well as voltage regulation and automatic illumination compensation, are built in, eliminating necessity of a separate power unit or multiconductor cable. Unit can be provided with either a long life, cold cathode or a pickup tube by the company, and multiple receiving points can be fed. **Diamond Power Specialty Corp.**, Lancaster, Ohio.

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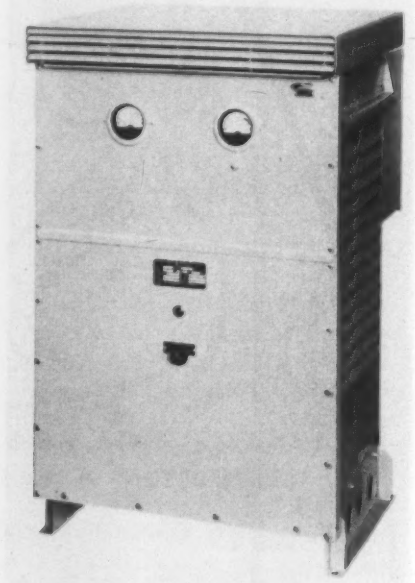

DC POWER RECTIFIER

No tubes, lamps, carbon piles or varistors are used in this compact dc power rectifier which is regulated by a unique magnetic amplifier control. Capacities up to 1000 amperes can be handled by ten 28-v production models in mobile or stationary units. Components are capsulated for dependable service under severe conditions, and weatherproof construction is of lightweight aluminum. Rectifiers are continuously variable between 25 and 29-v dc. Regulation is ±1 per cent with ±10 per cent change in ac input and any load variation from zero to full load. DC ripple is 2 per cent rms, and recovery time is 0.2 second. Units meet aircraft equipment and component specifications. **McColpin - Christie Corp.**, 3410 W. 67th St., Los Angeles 43, Calif.

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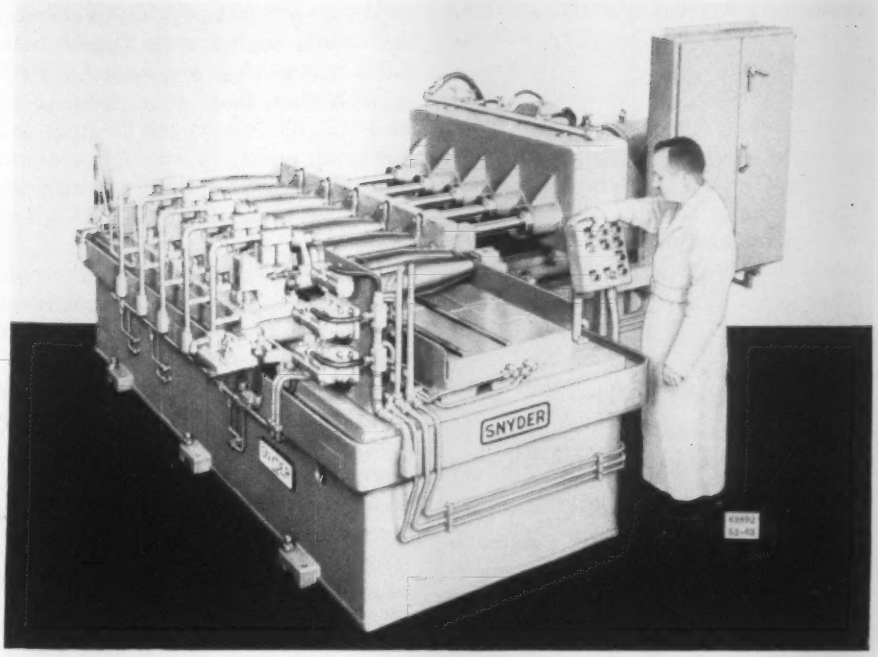

AUTOMATIC PROCESSING OF 155 MM SHELL CASES

Automatically cycled machine drills, counterbores, countersinks and reams 133 155-mm shell casings per hour in seven stations. Entirely automatic, the machine is electrically interlocked to protect operator and machine. Because the operation is basically the processing of burster tube recesses, which are located in the base of the shell and opposite the threaded throat in the nose of the shell, tools must reach into the shell cavity through this throat to machine the burster tube. Since the shell casing is approximately 22-in. long and 6-in. in diameter, tools must operate without support at a distance of 20-in., necessitating hollow spindles and central tube openings within the tools through which coolant can be fed. Coolant is supplied from a separately mounted tank and pump. When machine cycle is completed, a hydraulic mechanism tips the shell and empties coolant and cuttings through the throat in the nose. High speed steel tools operate at 70 fpm maximum with 4-in. per minute infeed and 25-in. stroke.

Operator rolls shell down an incline to a stop at the loading station where index mechanism lifts and carries it on. After it is automatically located and power clamped by pressure, supporting yokes fold down and clear the shell when index mechanism is returned. Processing is finished in five working stations, and shells roll from the machine on a ramp. Hydraulic cylinders govern all indexing, locating, and clamping motions. Machine occupies 135 x 145-in. floor space. **Snyder Tool & Engineering Co.,** 3400 E. Lafayette, Detroit 7, Mich.

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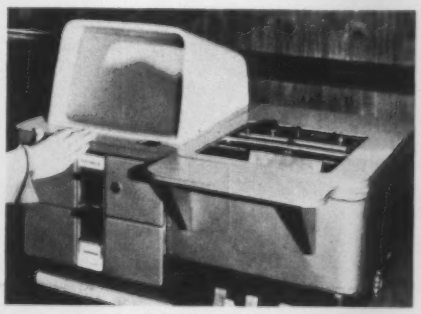


FILMS, PROJECTS DATA

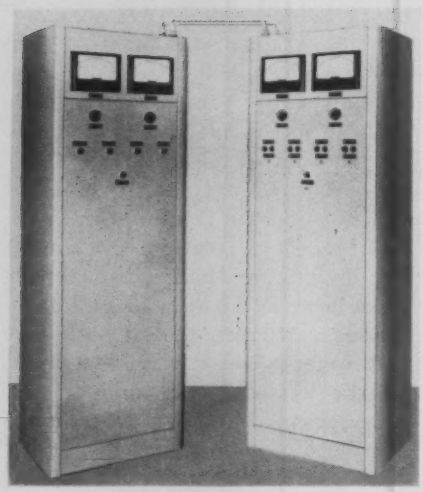
Micro-Twin, a compact, low-cost, portable machine, simultaneously reads and records both sides of documents for speedy processing of business data. Documents are automatically fed into machine by an attachment with an adjustable micrometer control. Control stops feed when documents overlap or are thicker than the micrometer setting. An immobilizing switch permits documents of varying thicknesses to be fed without changing micrometer setting. Leading edge of document turns on light to expose film which goes off when trailing edge passes. Automatic safeguards include an alarm for improper load of film and an alarm for a burned out lamp. Machine will not operate if lens is in incorrect recording position. Documents can be smaller than a bank check or as large as 11-in. wide and 3700-ft long. Mirrors record both face and reverse sides simultaneously. At the same time, the dual purpose lens projects image of document on an 8 x 11-in. reader screen. A 100-ft roll of 16 mm film records both sides of 14,000 checks or one side of 28,000 checks.

Facsimiles of filmed documents can be reproduced within five minutes without a dark room through use of sensitized paper which can be developed under office light conditions after exposure under hood. A film index meter automatically indexes film as documents are photographed to set up a filing system and simplify location of documents on reader. Frame is of rugged, lightweight aluminum covered with plywood, and working surface is of stain and burn resistant plastic. Entire machine measures 13½ x 23 x 32-in. **Burroughs Corp.,** 6071 Second Ave., Detroit 32, Mich.

Circle No. **10** *on Reply Card*

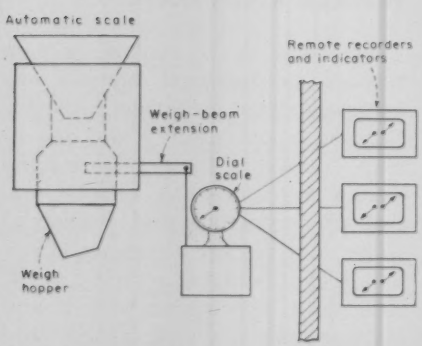
WATER CONTROL

As many as 30 control or continuous proportional signals can be transmitted in either direction between a transmitter and one or more receivers in a telemetering system for automatic remote control of municipal and industrial water and sewage equipment. Signals travel between outlying wells, reservoirs, processing basins, and storage facilities and central control centers. Normally using leased telephone wires or private cables, systems can provide float, pressure, bubbler or probe sensing devices. Signals are sent automatically to operate a number of devices, to report their operation, to sound alarm in case of imminent malfunctioning of the system, to give and record pressure or temperature readings on a continuous basis. All control and signal circuits are continuously monitored



by an automatic six second sampling of each circuit. System can take appropriate corrective action as soon as any change occurs. Transmitter and receivers are kept in phase by duplicate synchronizing circuits. When more than one receiver is used with a single transmitter, loop interconnections can be made by a single pair of wires between each unit. Transmitter has pilot light to show "action called for" for each control signal circuit, and all units have pilot lights to show "action accomplished" for each reporting circuit. Receivers and transmitter are each 20 x 24 x 76 in. **Automatic Control Co.,** 995 University Ave., St. Paul 4, Minn.

Circle No. **11** *on Reply Card*



INDICATORS, RECORDERS

Designed for weight control, remote indicators and recorders follow precisely a prime-mover dial scale which indicates weight of material being fed to an automatic scale's weigh hopper. These readings are synchronized and duplicated on an indicator in any remote location. Accuracy is said to be one part in 2000, or higher if necessary. Sixty-cycle servo system, which makes up the instrumentation, consists of a synchro transmitter, amplifier and a servo mechanism made up of a servo motor and control transformer. Recordings can be made on circular charts, strip units or tape printers. Units can be hooked up with any industrial scale dial, and any number of units may be run by the one prime-mover. **Richardson Scale Co.,** Van Houten Ave., Clifton, N. J.

Circle No. **12** *on Reply Card*

AUTOMATIC GRINDER

Downfeed, skipfeed, reverse crossfeed are performed automatically by a grinder which, with modifications, can adapt to either flat or contour grinding. Machine can be set up for hydraulic manual or automatic operation. Enlarged chuck size of 10 x 30-in. allows dresser to be positioned permanently at end of work table with adequate work area remaining, thus eliminating re-setups. Downfeed is calibrated in tenths, duplicated exactly in amount of stock removed by wheel. Belt-driven spindle runs off 3 hp. Models are available with wheels sized from 10 x ¾-in. to 14 x 2-in. While unit can be equipped with automatic lubrication system, an independent system can be used when necessary to suit JIC specifications.

A coolant is fed through the porous wheel and across the surface of cutting crystals to prevent heat build-ups. If necessary, the workpiece can be flooded to reduce heat. Baffled, heavily filtered coolant recirculates through the machine. Limit switch controlling automatic downfeed can be set with micrometer precision. Automatic crossfeed reverse is used in conjunction with downfeed for surface grinding. Crush form grinding table controls automatically supply a slow powerful table drive as required by heavy downfeed speeds. Drive can be as slow as 1-in. to 75 fpm. Unique skipfeed device utilizes a rapid traverse valve, built into saddle, and "skip" dogs on table to speed up table movement between work-

pieces when machine is grinding a number of parts at one time. Optional features available for wheel include: a crush dress spindle drive for crush forming the wheel; two variable speed spindle drives, a low range unit providing up to 4000 rpm, and a high range unit with speeds up to 20,000 rpm; a horizontal-vertical, high-speed spindle attachment; cylindrical grinding attachments; crush roll stands and crushing rolls; electromagnetic chucks, sine chucks, chuck controls; wheel balancers; dust collectors. **DoAll Co.,** Des Plaines, Ill.

Circle No. 13 *on Reply Card*

SPEED CONTROL

A pneumatic control system is engineered to automatically regulate variable speeds in company's Varidrive motor. Known as the Varitrol, this device permits drive speed to be controlled by pressure, temperature, humidity, viscosity, flow rate, liquid level, tension, weight, position in relation to mechanical motion, CO_2 gas content, pH value, and electrical signals.

Varitrol is a pneumatic amplifier consisting of a high pressure power system which is controlled by a low pressure signal system to operate a piston in a cylinder which in turn acts upon the drive's speed control lever. A supply air pressure of 60 to 100 psi operates the control. This air passes through a solenoid valve which shuts off main air supply as the Varidrive is de-energized, providing automatic return to low speed for protection of the equipment. Air is next filtered and regulated to correct operating pressure by a gage, is then sent by a "T" connection to the positioner where the low signal air pressure controls the flow of power air to the piston drive in the cylinder. Power air provides force for piston's downward thrust and for lever's increasing the speed of the Varidrive. The second branch of the "T" connection sends air through another regulator where it is reduced to 5 to 15 psi to furnish cushioning air for reverse power for the piston and to decrease speed of the drive as the power air is reduced. Positioner guarantees constant relationship between sig-

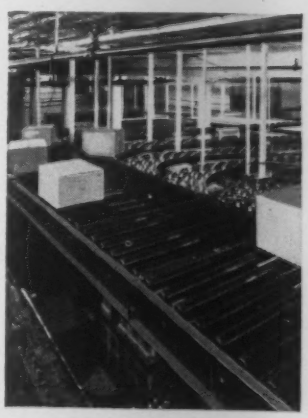
ON BUSCHMAN CONVEYORS

Across industry . . . in plants of all types . . . BUSCHMAN conveyors are setting new records for materials handling economy and efficiency. Engineered to individual production needs, these conveyor systems streamline plant operations . . . eliminate bottlenecks . . . reduce manual handling to absolute minimum.

BUSCHMAN offers a wide range of types and sizes to cover widely diversified materials handling applications. Gravity roller and wheel . . . live roller . . . powered belt . . . apron . . . overhead cable . . . or special conveyors can be supplied. In addition, BUSCHMAN engineers are prepared to survey your plant and to recommend the most practical, economical and efficient type of conveyor for each installation.

Whatever your materials handling requirements . . . specify BUSCHMAN for durable, versatile, profitable conveyor systems.

BUSCHMAN-designed switch and spur sections provide maximum versatility.



Typical combination system utilizing live rollers and gravity wheels.

C-1733-EWB

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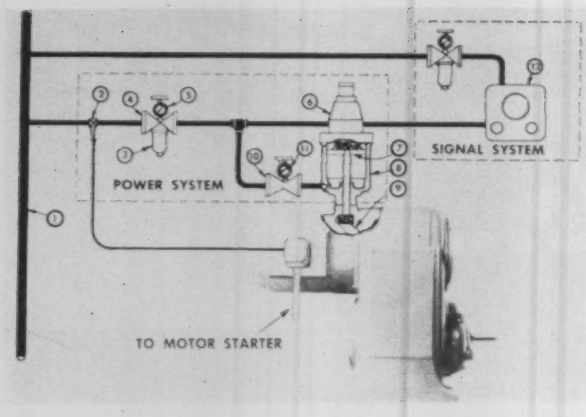


SCHEMATIC DIAGRAM

1. Customer's air line 60 – 100 psi
2. Solenoid operated valve
3. Air filter
4. Pressure regulator
5. Pressure gauge
6. Positioner
7. Piston
8. Air cylinder
9. Varidrive speed changing lever
10. Pressure regulator
11. Pressure gauge
12. Primary control instrument

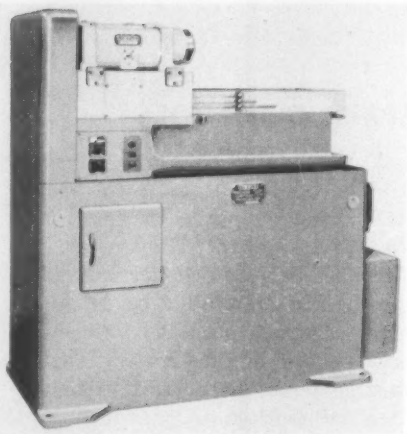
nal pressure and rpm regardless of variation in friction forces which may be in opposition to speed shifting. Shift from one extreme of speed range to the other takes as little as 3 to 4 seconds in small units and 7 to 10 seconds in larger units.

Signal system depends on a control instrument operating on 20 psi to furnish 3 to 15 psi variable signal pressure which is transmitted to positioner. By means of a diaphragm and valve, positioner regulates power air as required to obtain proper speed change. Varidrive motors are available from ¼ to 30 hp with speeds from 14 to 14,000 rpm, can be furnished with 50 hp in horizontal or upright assemblies. Ideal applications of the combined drive and control include control of proportional flow, combustion control, proportional conveyor control, predetermined programs of speed rates, rewinds, and filtration. **U. S. Electrical Motors Inc.,** Box 2058, Los Angeles 54, Calif.

Circle No. **14** *on Reply Card*

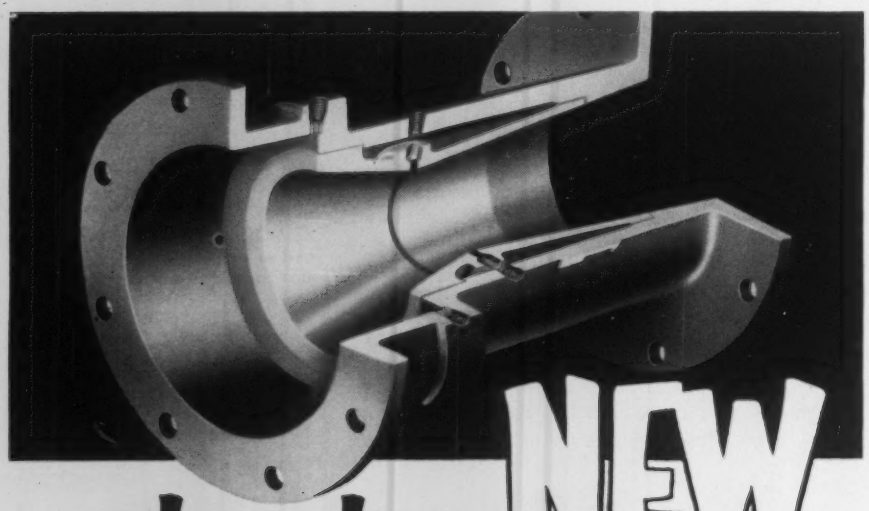
PRECISION BORING

Mechanical, automatic feed precision boring machine is cycled for rapid traverse, coarse feed, fine feed, dwell, and rapid return. Pushbutton initiates cycle which is then controlled by limit switches. Trip dogs adjust length of feed and length of rapid traverse. Another pushbutton stops the machine at any time during the cycle, and emergency return allows table to be returned at any time. Feeds from 1½ to 13½-in. per minute



are available, and feed change gears provide feed changes. Additional reversing feed is available. **Simplex Machine Tool Corp.,** 4548 W. Mitchell St., Milwaukee 46, Wis.

Circle No. **15** *on Reply Card*

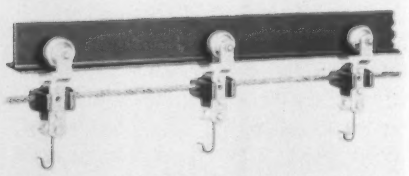


DALL Low-Loss FLOW TUBE

This primary metering device produces important pumping economies by reducing meter head loss to a minimum. Very short laying length – only 1½ to 2 pipe diameters. Lightweight and easy to install. Meters very accurately with regular differential-type instruments. Send for Bulletin 115-L1. Builders-Providence, Inc., 527 Harris Avenue, Providence 1, Rhode Island.

BUILDERS-PROVIDENCE
DIVISION OF B-I-F INDUSTRIES, INC. METERS FEEDERS CONTROLS

See us at the Instrument Exposition in Philadelphia

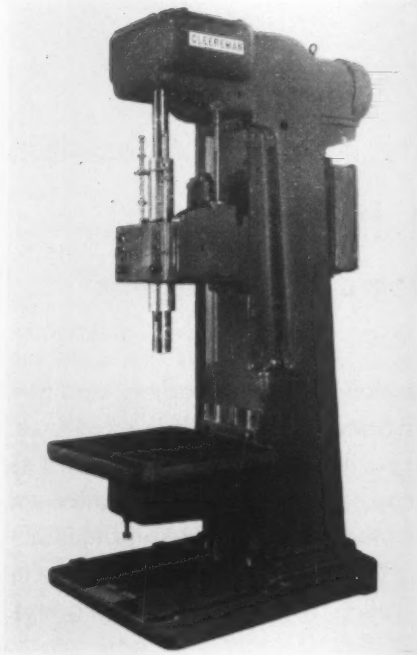


CABLE CONVEYOR

Cable life is said to be increased more than 30 times on new Bush-Lock cable conveyors. Cylindrical bushings are permanently locked on accurate centers by high pressure swaging to preformed galvanized or stainless steel cable. Two halves of the adaptor block, to which trolley and loading hook are attached, bolt around bushing. Rotary floating action of the bushing in the adaptor block plus its ease of lubrication result in increased cable life. Systems are easily installed, maintained, revised, and

expanded. Shorter radius horizontal and vertical curves conserve floor space, permit compact layout. Conveyors will transport parts through cleaning and painting as well as assembling processes, can be used as overhead storage facilities. They travel between floors and buildings if necessary. Cable is ¼-in. with Bush-Locks at 12 and 15-in. centers, and ⅜-in. with bushings at 12-3/32 and 15-1/16-in. centers to operate on standard sheaves. Nine wheel types are available to suit various operating conditions. **E. W. Buschman Co.**, 4544 Clifton Ave., Cincinnati 32, Ohio.

Circle No. **16** *on Reply Card*



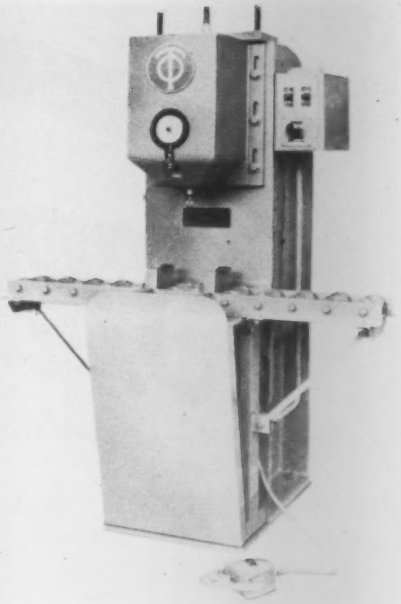
DRILLING AND TAPPNG

Electromechanical drilling and tapping machine has automatic cycle which is initiated by push-button and controlled by dogs. One set of dogs controls feed cycle with a micrometer depth control dog, and another set of dogs controls power rapid traverse approach and return. In addition to the rapid traverse approach, feed, and rapid traverse return, the automatic cycle contains tap-in and tap-out movements for tapping operations. Foot switch or auxiliary pushbuttons, as well as fixture interlock switches, can be used. Speed ranges from 60 to 1725 rpm, with feed range from approximately 0.003 to 0.250-in. per revolution. All standard pitches of tap leads up to ¼ pitch are available. Drive is 10 hp. No. 5 Morse taper spindle is standard but flanged spindles for multiple spindle heads can be supplied. Transmissions have anti-friction bearings and are automatically lubricated. Standard top section can be furnished alone for installation on special fixtures and transfer machines. **Cleereman Machine Tool Co.**, 640 W. Washington Blvd., Chicago 6, Ill.

Circle No. **17** *on Reply Card*

TESTER FOR HARDNESS

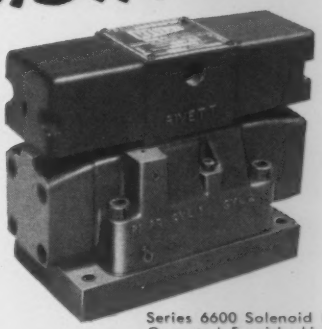
A conveyorized Brinell hardness tester, designed for incorporation into a production line, will test specimens at the rate of ten per minute. Built-in roller conveyor is supplemented by an air-operated lift which quickly places each specimen in test position. After positioning, a preset load of 500 to 4000 kg is applied to specimen by a steel ball and held for period set on an electric timer. Specimens satisfying tolerance requirements are returned to conveyor and rejects are removed from tester. Foot pedal controls all operations. Machine will accommodate specimens up to 12 in. in diameter or the equivalent. **Tinius Olsen Testing Machine Co.**, 1050 Easton Rd., Willow Grove, Pa.



Circle No. **18** *on Reply Card*

SHOCK RESISTANT!

Rivett 3000 P.S.I. sub-plate mounted hydraulic valves



Series 6600 Solenoid Pilot Operated. Furnished in ½", ¾", 1", 1¼" and 1½" I.P.S.

Spool features a scalloped design and built-in metering grooves, permitting easier, faster flow and reducing impact. Unrestricted passages allow greater flow capacity—¾" size rated at 28 G.P.M. at 15 ft. per sec.! Four extra long sealing surfaces on the spool provide extremely close fit with valve bore.

FEATURES

1. Continuous duty, shock-mounted solenoids. 3.6 amps inrush; .45 amps holding at 115V.
2. Roomy wiring box. Dust, moisture sealed. ½" conduit connections.
3. 7 spool designs for 3 and 4-way.
4. Less pressure drop.
5. Mounted in any position.
6. Extra long sealing surfaces.

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VALVES • CYLINDERS • POWER UNITS

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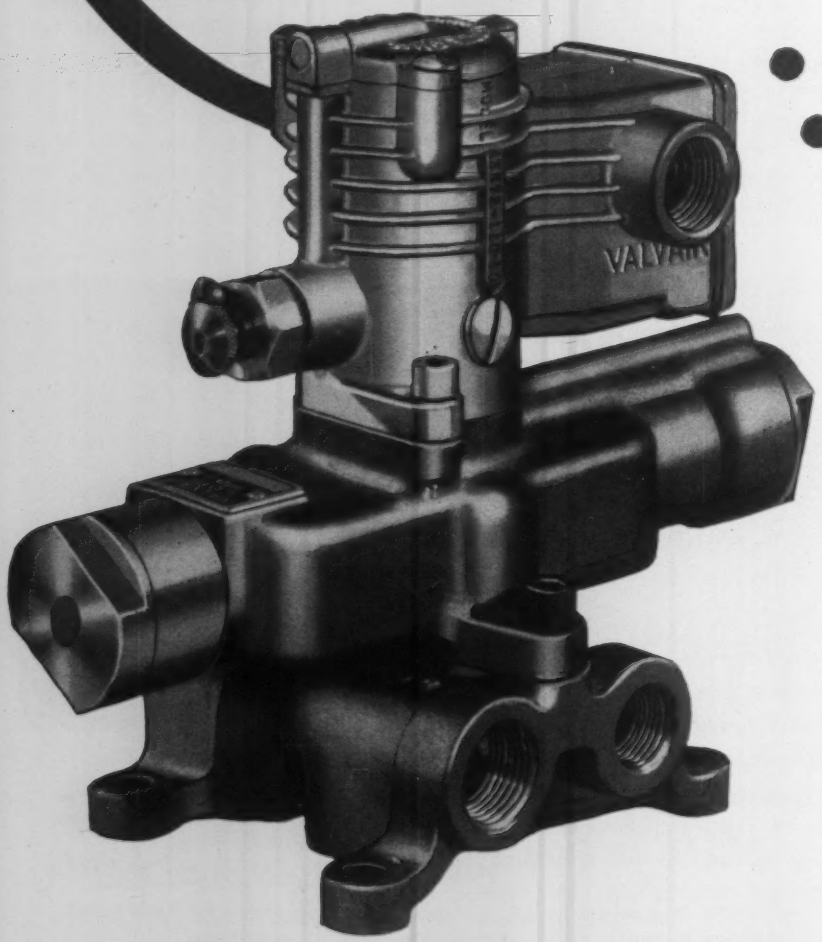
SOLENOID PILOT OPERATED CONTROL VALVE

by VALVAIR

DESIGNED AND BUILT TO J. I. C. STANDARDS



- **A Hefty Assist to Automation**
- **Fully Enclosed**
- **Integral Junction Box**

The Valvair line broadens again — with Speed King's exclusive features. All parts are totally enclosed. The Speed King will operate submerged in water or buried in sand. Simplicity! — only two moving parts. Molded coil — no wear or shorting out. 20,000,000-cycle life and more. Speed King is industry's most rugged and compact valve.

Other features: for pressures from 35 to 200 p.s.i. pneumatics, hydraulics, vacuum; complete line—2-way, 3-way, 4-way and 4-way-5-port (2-pressure) models; foot or sub-base (manifold) mounting; pipe sizes —¼", ⅜", ½", ¾", and 1".

Ask for Bulletin "A-9".

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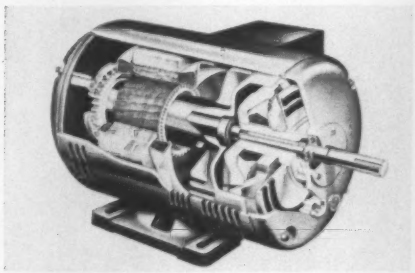
VALVAIR CORPORATION *Affiliate: Sinclair-Collins Valve Company*
1011 BEARDSLEY AVE., AKRON 11, OHIO

Rely Upon Valvair DIVERSATILITY

AUTOMATION NEW COMPONENTS



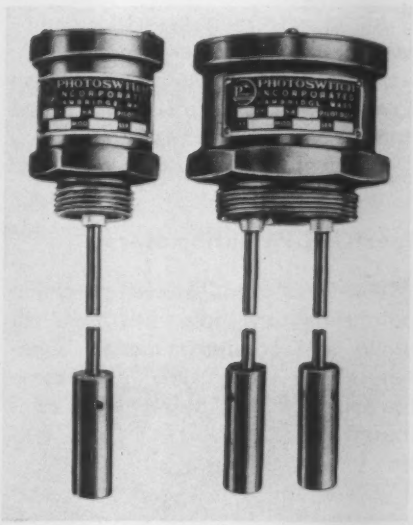
Control of Fractional HP Drives

Combination ac constant speed induction motors, eddy-current couplings, and electronic speed controls act as power and speed controls for fractional horsepower drives. Adjusto-Spede drives are adaptable to many applications requiring controlled adjustable speeds such as drives for business machines, printing presses, machine tools, conveyors, wire drawing equipment, welding machines, metal and paper rewind, and laboratory experimental machines. Drive can operate continuously at any speed within its range limits while under constant torque or fan type load. Speed stability of ±2 per cent is insured by electronic control. Only wiring necessary is a simple connection to a standard single or three-phase electrical power line, and only a minute current is required for remote control operations. Drive is available in 115/220 v, single-phase, or 220/440 v, three-phase; in ¼, 1/3, and ½-hp at 1600 rpm with 10:1 constant torque speed range; and in ½ and ¾-hp at 3200 rpm with 20:1 range. Units can be mounted on wall, ceiling, or floor. **Dynamatic Div., Eaton Mfg. Co.,** Kenosha, Wis.

Circle No. **19** *on Reply Card*

Liquid Level Probe Fittings

Flexible, long lived, maintenance free probe fittings are designed for use with company's standard level controls to operate in control of all electrically conductive liquids. Stuffing boxes, floats, all moving parts which could wear and fail have been eliminated. Liquid itself provides the path for a minute electric current which actuates the level control to start or stop



pumps, give alarm, or perform any control function. For a variety of operations, several probe fittings can be mounted in the same tank. Probe rods are Teflon insulated to withstand attack of most chemicals and boiling solvents, and to insure high insulation resistance even in saturated atmospheres. A variety of housings is available, including bronze, cast iron and stainless steel, to meet all installation requirements, and all contain threaded openings for conduit connections. Fittings adapt to probe lengths from 2¾-in. to 9-ft, and can be had with insulated suspension wire and heavy probe tip for longer lengths. Maximum operating temperature is 300° F, and maximum pressure is 250 psi. **Photoswitch Inc.,** 77 Broadway, Cambridge 42, Mass.

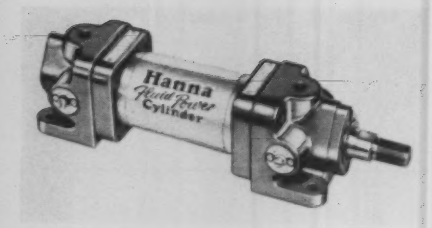
Circle No. **20** *on Reply Card*

Automatic Adjustable Timer

An adjustable, synchronous timer for production and sequence timing can be run for an hour, any part of an hour, or can operate continuously, repeating a sequence indefinitely. One to twelve circuits are available, and manual pushbutton control of any one of them is possible whether machine is in automatic or manual operation. A safety switch cuts all circuits as soon as timer door is opened to change the master cam cylinder. Snap-action contacts are single pole, double throw, 15 amp, and will operate on 110-115 or 220-230 v ac circuit. Cycle is started manually by turn of a knob, each circuit is performed, and cycle stops automatically upon completion or can be set to repeat sequence indefinitely. Change in circuits can be accomplished rapidly by removing master cam cylinder and altering its

circuit pattern. Timer adapts to automatic operation of any industrial equipment which requires a sequence of turn cycles. **Unit Wash Corp.,** 162 S. Washington St., Plainville, Conn.

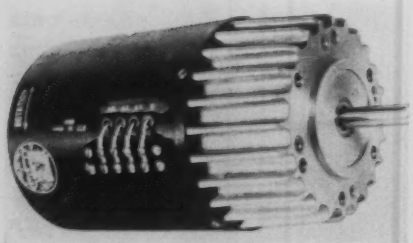
Circle No. **21** *on Reply Card*



Fluid Power Cylinder

Featuring large capacity as compared to unit's compact size, a new line of hydraulic or air cylinders will handle up to 750 psi. A new cushion design has been incorporated into cylinder for positive cushioning over full stroke and for easy speed adjustment. Friction has been reduced to a minimum that is consistent with positive sealing. Pistons of steel and heads of high strength alloy iron are resistant to corrosion. **Hanna Engineering Works,** 1751 Elston Ave., Chicago 22, Ill.

Circle No. **22** *on Reply Card*



Radar Antenna Drive Motor

An instant reversing, capacitor start and run induction motor is designed for radar antenna drive. Motor is single-phase, 115 v ac, 60-cycle. Running torque is 430-oz-in. at 1475 rpm, locked rotor torque is 500-oz-in. at zero rpm, and pull-out torque is 700-oz-in. at zero rpm. Stainless steel shaft and hardware and ball bearings are used, frame is totally enclosed. **Mission-Western Engineers, Inc.,** 132 W. Colorado St., Pasadena 1, Calif.

Circle No. **23** *on Reply Card*

Transformer for Power Supplies

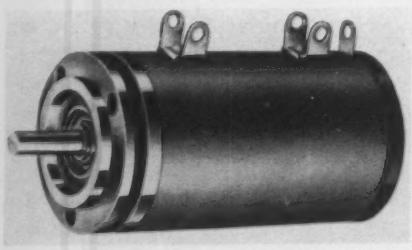
Instrument power supply transformers are designed specifically for use in voltage regulated supplies, cathode ray tube supplies, vacuum tube voltmeters and preamplifiers. Special features are multiple filament windings for use with tubes operating at different potentials, minimum flux density cores which limit stray magnetic fields in extremely sensitive equipment, and multiple static shields to limit capacitive coupling. **Triad Transformer Corp.,** 4055 Redwood Ave., Venice, Calif.

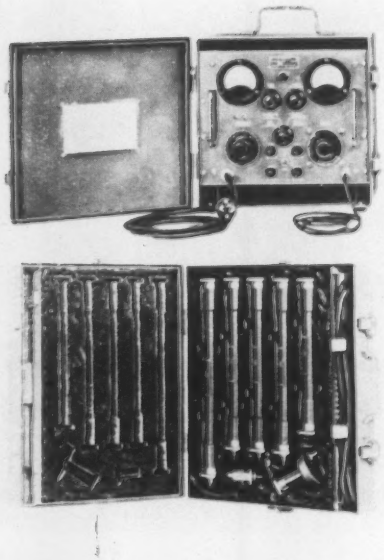
Circle No. **24** *on Reply Card*

Precision Potentiometers

Ten-turn miniaturized precision potentiometers are available in linear and nonlinear models, combine high resolution and close linearity or conformity with minimum size and weight. Only 1½-in. long and ⅞-in. in diameter, and weighing only 1.1 oz, the unit contains an 18-in. long mandrel-wound resistance element for resolution as fine as 0.01 per cent. Linear models have standard resistance range of 25 to 100,000 ohms, with tolerance of 0.5 per cent and possible improvement to 0.1 per cent on special order. Conformity tolerance in nonlinear models is ±1 per cent with much closer conformity available on special order. Models are furnished with servo lid and precision miniature ball bearings, with servo lid and sleeve bearings, or with threaded bushing and sleeve bearings. Terminals are gold plated, and power rating is 2 w at 40° C ambient temperature. **Helipot Corp.,** 916 Meridian Ave., South Pasadena, Calif.

Circle No. **25** *on Reply Card*





Pulse, CW Power Measurement

Broadband power meter is available in six models to cover frequency range of 20 to 10,000 megacycles for average power levels of 20 mu w to 5 w, and measures both pulse and continuous wave power accurately. Instrument gives direct reading of average power, is suitable for field or laboratory use and for any application requiring accurate measurement of radio frequency or microwave power. Meters can be used with television systems, or on a production line to measure output of signal generators, transmitters, or radio frequency power standards. Meter has automatic compensation for temperature and frequency drift, broadband radio frequency components with low voltage standing-wave ratio values, and a dc summation bridge. Kit of precision broadband components, furnished with each instrument, contains attenuators, bolometer mount, five bolometer ele-

ments, radio frequency cable, and 7/8 to 3/8-in. adapter. True square-law response of bolometer elements is maintained accurately for both pulse and continuous wave power. Overall accuracy of measurements at any power and frequency range, at ambient temperatures between −40 and 55°C is within 5 per cent of absolute value. **Bruno-New York Industries Corp.**, 460 West 34th St., New York 1, N. Y.

Circle No. **26** *on Reply Card*

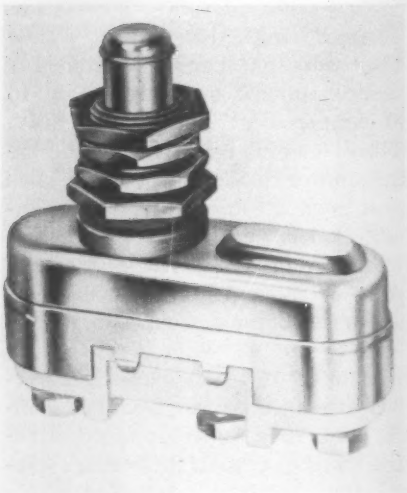
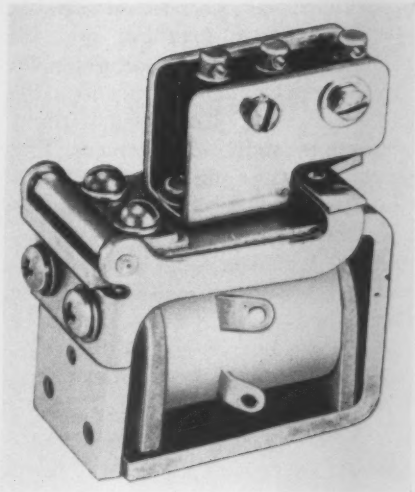


Plate Circuit, Sensing Relays

Line of relays for plate circuit use and current and voltage sensing features snap switches which provide such positive and instantaneous on-off action that drop-out voltage or current is only 1 per cent of the pull-in voltage or current. Close overlap action is obtained with both constant current and constant voltage circuits. Two basic types of relay are available: a highly accurate precision relay for identical repetition which is shock and vibration resistant; and a less complex on-off duty relay for less critical, exacting applications. Model illustrated is RL-516, a single pole, double throw relay with 6400 ohm coil which pulls in at 4 ma and drops out at 2 ma (3.95 ma with a detent resistor). This model's coil resistance is up to 18,000 ohms and its sensitivity is as low as 80 milliwatts. Relays are available in 1, 2, 3-pole or more units as required. **Joseph Pollak Corp.**, 81 Freeport St., Boston 22, Mass.

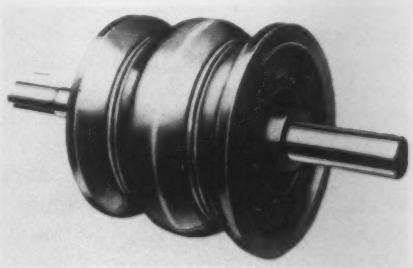
Circle No. **27** *on Reply Card*



High Temperature Switch

High temperature applications are ideal for a new precision switch which can transfer substantial electrical loads in a temperature range of −50 to 1000° F. Industrial applications such as vulcanizing plant operations, as well as high temperature aircraft applications, are suitable. Switch has life expectancy of over 25,000 operations at 700° F at a resistive load of 5 amp, 28 v dc. At 1000° F, and carrying a resistive load of 2 amp, 28 v dc, the switch has surpassed 9000 operations. Unit has been designed for panel mounting. **Micro Switch, Minneapolis-Honeywell Regulator Co.**, Freeport, Ill.

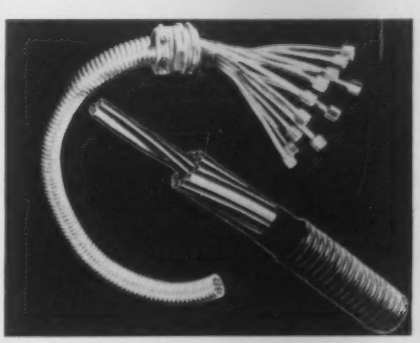
Circle No. **28** *on Reply Card*



Galvanized Pipe Dragout Rolls

To remove steel pipe from large vats of molten zinc, nonelectric, magnetic dragout rolls are usually installed in pairs to handle two lines of pipe simultaneously. Each roll is V-contoured, 17½-in. in diameter, 8-in. wide, and capable of handling pipe from ½ to 4-in. in diameter. Rolls are mounted on a common shaft and aligned under a heavy frame which slopes upward away from the galvanizing pot at a 15° angle. All units rotate at equal speed. End of pipe is lifted from pot by a hook, placed in contact with lower side of first dragout roll, held firmly by magnetic force of rotating unit, and quickly drawn from pot and passed to succeeding units in the line. Pipes can be allowed to overhand to final roll to a point where they fall or are easily pushed off, or can pass to electromagnetic units which drop them automatically when they pass and trip a flag type switch. Magnetic units will withstand heat, steam, acid fumes, vibration, and impact. **Eriez Mfg. Co.**, 1945 Grove Drive, Erie, Pa.

Circle No. **29** *on Reply Card*



Armored Multitubes

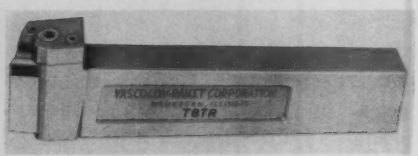
Armored group of long length tubes twisted together to permit bending without distortion saves time and cost in installation, is long lived, and can be inserted in inaccessible or hazardous spaces with no injury to tubing. One-half in. and smaller tubes are used with process control equipment and instruments. Two to nineteen tubes, ¼-in. OD, are available in copper and aluminum. Other tubes are available in polyethylene and plastics, also. Long continuous lengths, up to 1000 ft, save waste and short ends. One tube in each layer is blue for ready identification of each tube at both ends. Tubes are protected by flexible interlocked galvanized steel armor and insulated with tape to prevent electrogalvanic action due to contact of dissimilar metals. **Crescent Insulated Wire & Cable Co.**, 319 N. Olden Ave., Trenton, N. J.

Cirlce No. **30** *on Reply Card*

Rotary Speed Control

Mechanical-electrical translator for automatic control of rotary speed is available in two models; one will open or close any desired electric circuit at a predetermined rpm, and the other is a multi-speed instrument for automatic control of a sequence of operations. Translator adapts to variety of automatic controls of rpm. Only 2½-in. in diameter and 4½-in. high, unit fits standard Army-Navy mounting pad and is already installed on military aircraft. Originally designed to prevent overspeeding of aircraft engines and helicopter rotors, translator can be mounted in any position and is easily adjusted to operate at any rpm. Range is 1200 to 5000 rpm with accuracy plus or minus 2 per cent. Industrial applications include bottling, food processing and canning, and many assembly-line applications. **Kahn & Co., Inc.,** 541 Windsor St., Hartford 1, Conn.

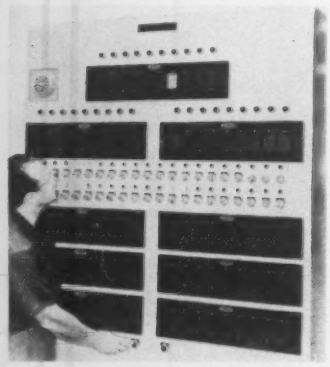
Circle No. **31** *on Reply Card*



Chipbreaker, Blanks in Holder

A new toolholder for carbide tooling features a built-in carbide chipbreaker, which provides correct chip formation over wide cutting range for single chipbreaker width, and "throw-away" blanks, which are used on all cutting edges without grinding and then thrown away. Blanks are available to fit triangular, square and round toolholders. The combination of blanks and chipbreaker eliminates all chipbreaker grinding and all carbide grinding. Toolholder is available with neutral or negative rake, and rake is changed without removing toolholder from tool post. Cutting edge is kept positioned automatically by toolholder and a new edge is obtained by merely indexing or changing insert. Cracked tools due to brazing strain are eliminated as is loss of a complete brazed tool due to carbide failure. **Vascoloy-Ramet Corp.,** Waukegan, Ill.

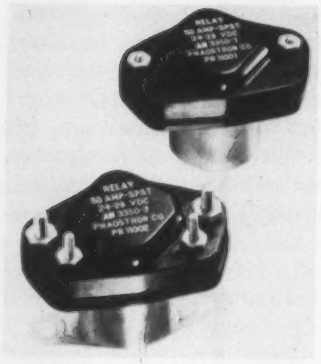
Circle No. **32** *on Reply Card*



Sequence Alarm System

A sequence annunciator system pin points cause of trouble when a process shuts down by locating exactly which variable first went "off-normal". Automatic lock-out of subsequent signals, or first signal's appearance in red and subsequent signals in white, indicate source of trouble. Push-button reset causes sequence indication to start over again. Signals are grouped for sequential lock-out by simple jump connections on the rear terminal block. Any number of inter-related groups may be formed or interchanged. All relays, contacts and moving parts are sealed hermetically in plug-in units. Additional signals may be added to chassis by simply adding plug-in units. Backlighted nameplate cabinets provide from 3 to 48 signals. Alarm system is suitable for use in compressors and in process applications, particularly dangerous processes where entire process must be shut down when trouble starts. **Panalarm Products, Inc.,** 6312 N. Broadway, Chicago 40, Ill.

Circle No. **33** *on Reply Card*



Fifty-Amp Relay

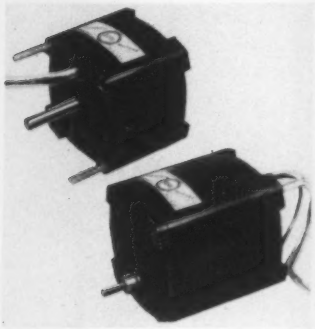
Sealed single pole single throw relay acts as magnet switch for remote control of currents up to 50 amperes at continuous duty. Relay meets resistive, inductive and motor loads of 50 amp, has been successfully subjected to 50,000 cycles at its rated resistive load. Nominal operating voltage is 24 to 28 v. Unit has been tested to withstand temperatures of −55 to 70° C, shock at 26 g, vibration of 10 to 55 cycles per second at maximum excursion of 0.06-in., and 10 g continuous acceleration without malfunctioning. Insulation between grounded parts and terminations withstands potential of 100 rms for 60 seconds. Mounting brackets are optional. **Phaoston Co.,** 151 Pasadena Ave., South Pasadena, Calif.

Circle No. **34** *on Reply Card*

Servomotors

Seventeen variations are available in a new line of high temperature servomotors. These units operate in regions of 160° C (320° F), and can be fitted with a variety of plain or pinion shafts. Ratio of torque to inertia is high. Motors meet all military humidity, saltspray and fungus requirements. **American Electronic Mfg., Inc.,** 9503 W. Jefferson Blvd., Culver City, Calif.

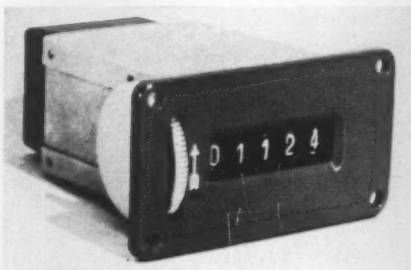
Circle No. **35** *on Reply Card*



Fractional Motors

Enclosed electric motors have ratings of 1/2000, 1/1500, 1/1000 or 1/750 hp, and operate on 115 v, 60-cycle current. Special voltages and frequencies are available if required. Motors can be either 2 or 4-pole, synchronous or induction type, with or without internal gear train. Similar fractional motors have been used by the manufacturer in watch rate recorders and similar precision equipment. Entire series is now available to the electrical industry. **Borg Equipment Div., George W. Borg Corp.,** 120 So. Main St., Janesville, Wis.

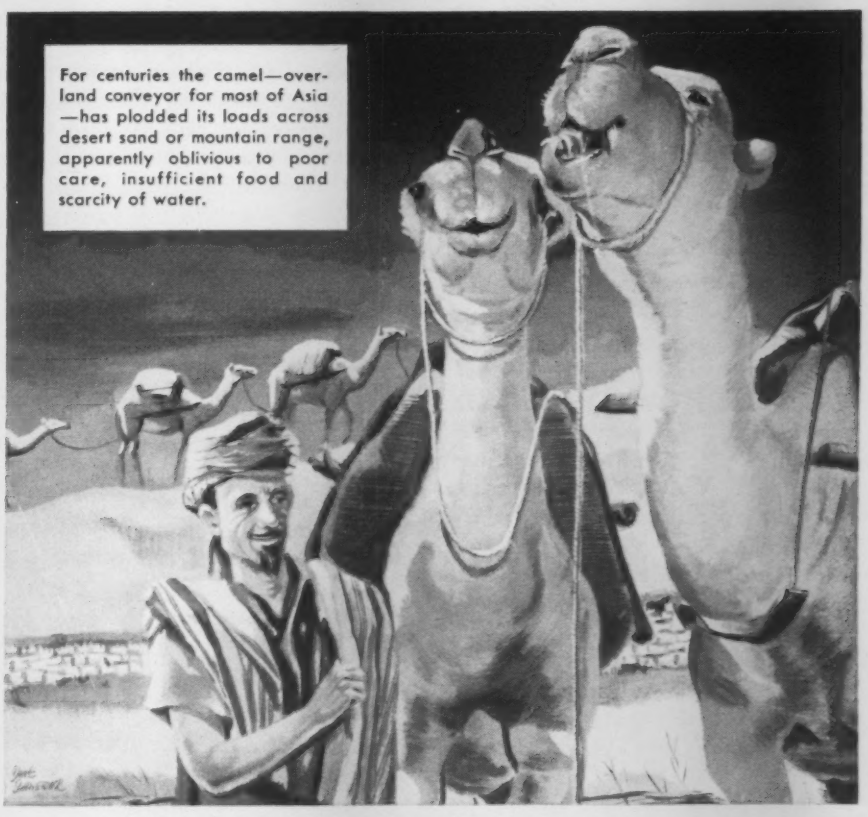
Circle No. **36** *on Reply Card*



Electrical Impulse Counter

Manufactured in Germany, an electromagnetic counter is fast, compact, and accurate, and is said to have a life expectancy of eight times that of most comparable counters. The instrument is designed specifically for panel mounting, has five digits, all of which are reset to zero by one turn of a knob. Power consumption is 8 w, and unit operates on 6 to 220 v, ac or dc. Count can be as high as 1200 per minute. Size is 1¾ x 1 3/16 x 2½-in. Represented in U. S. by **Presin Co.,** 5225 Wilshire Blvd., Los Angeles 36, Calif.

Circle No. **37** *on Reply Card*


For centuries the camel—overland conveyor for most of Asia—has plodded its loads across desert sand or mountain range, apparently oblivious to poor care, insufficient food and scarcity of water.

MASTERS OF **TOUGH** CARRYING JOBS

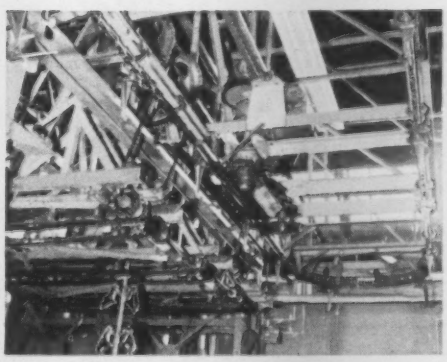
It is a far cry from this ancient camel-back conveyance to the ingenious Automation Equipment conceived and built especially for modern industry.

Today—many manufacturers, who have been plagued with inefficient, outmoded material handling equipment, look to *Allied* for solving their problems, however complex.

You, too, can depend on *Allied* for the perfect solution to your particular conveyor problem. Their long-time experience, engineering know-how and fabrication facilities can be yours on request.

See for yourself why *Allied* Conveyor Units, mile-long Conveyor Systems or Specialized Handling Machines are recognized *masters of the toughest carrying jobs!*

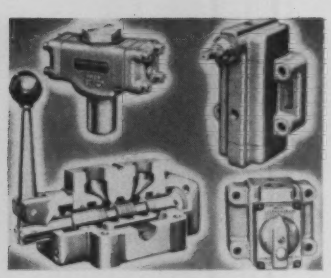
PIONEERS IN AUTOMATION . . . *the design and fabrication of fully automatic mechanical handling systems*



One type of custom built, special purpose material handling system engineered by Allied is this plating and dipping installation that includes several conveyors, separately driven at different speeds, and provides two automatic load transfers.

For further information request Allied Catalog 953

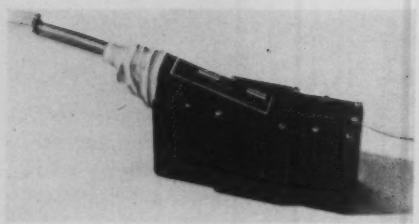
ALLIED AUTOMATION DIVISION
ALLIED STEEL and CONVEYORS, INC.
17365 Healy Avenue, Detroit 12, Michigan



New Hydraulic Valve Line

More than 3500 models are available in company's new, revised line of hydraulic valves. Superior performance is attributed to full floating operating lever on directional valves, "O" ring seals on each end of body for leakproof operation, full flow design for minimum pressure drop, and interchangeable end caps for changing valve assembly to reverse valve ports. Both directional and functional valves are represented in the new line, each valve being available with optional body style and control. Directional valves may be threaded, flange or gasket mounted for pressures up to 3000 psi. Controls include stem, knob, lever, and a quadrant lever locking device for safety. Functional valves for relief, sequence, unloading, pressure reducing, counterbalance, flow control and check can be threaded for pressure of 2000 psi, flanged for 3000 psi, and gasket mounted for 2000 and 3000 psi. **Hydraulic Power Div., Hydraulic Press Mfg. Co.,** Lincoln Ave., Mount Gilead, Ohio.

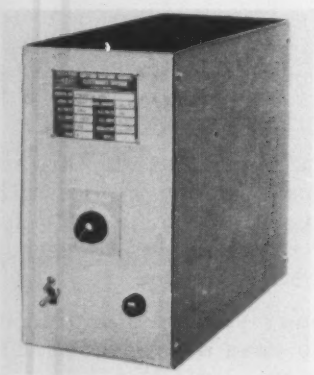
Circle No. **38** *on Reply Card*



Impulse Generator

Originally developed to military aircraft specifications as an emergency standby unit to set off explosive charges for forced ejection of external stores and bombs, this impulse generator is suitable for such commercial and industrial applications as mining devices, railway signals, alarm systems, flash bulbs, operation of solenoids, or any application requiring an electrical impulse yet having only a slight mechanical force available. Generator converts mechanical energy into pulses of electrical energy, restores itself after operation without application of additional force. Successful operation under water makes unit suitable for marine applications, and no maintenance or adjustments are necessary. Generator has no stored potential energy to cause premature or unintentional operation. Illustrated model delivers 5½-w for pulse duration of 25 milliseconds or longer, measures 5½ x 2 x 3¾-in., and weighs 2¾-lb. **Microloc,** 5811 Marilyn Ave., Culver City, Calif.

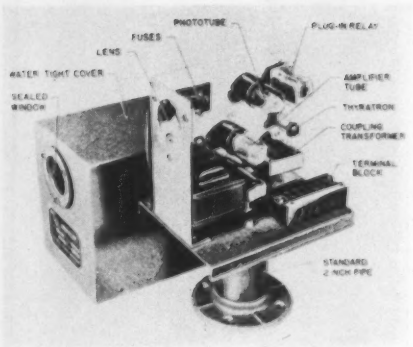
Circle No. **39** *on Reply Card*



Voltage or Current Regulator

Rota-Mag is adaptable to all dc and 60-cycle ac generators as well as to high cycle alternators. It can be used to regulate generator output of voltage or current in production line testing, engine starting, pre-flight checkout, dc electroplating and anodizing. Regulated by a magnetic amplifier which eliminates fragility, wear, and maintenance of electronic parts, regulator is so sensitive that less than 0.4 v deviation in generator's output voltage will cause magnetic amplifier to make a full swing. Response to full load can be as rapid as 0.2 seconds. **Electronics Div., Hufford Machine Works Inc.,** 2201 Carmelina Ave., Los Angeles 64, Calif.

Circle No. **40** *on Reply Card*



Light Beam Relay

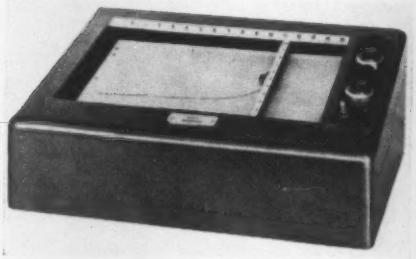
A modulated light beam relay operates on pulsed rather than steady light for such "electric eye" applications as door openers, press and shear safety guards, conveyor controls, and intrusion alarms. Light from a projector is pulsed several hundred times per second by a scanning disc with holes at its outer edge. Receiver is tuned only to this frequency by resistance-coupled circuits and a peaked transformer coupling. Unit cannot be triggered by ambient light changes or reflections, or flashlights. Relay has watertight, dustproof, welded steel case, reduced voltage light source, a plug-in relay with 5 amp, double-pole, double-throw control contacts, and an optional infra-red filter. **Electronic Control Corp.,** 1573 E. Forest, Detroit, Mich.

Circle No. **41** *on Reply Card*

Easily Assembled Fittings

Leakproof tube fitting is delivered with nut already in body so that handler simply inserts tube into fitting body and tightens nut. This shears sleeve from end of nut and causes it to attach itself tightly to tube for pressure tight and leakproof joint. Fittings will withstand vibration. Pipe threads are long dry-seal. Most sizes are available in brass, aluminum, steel and 316 stainless. **Dekoron Products Div., Samuel Moore & Co.,** Mantua, Ohio.

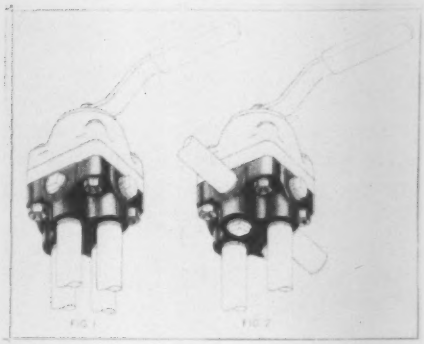
Circle No. **42** *on Reply Card*



Large Flat Bed Graph Recorder

Designed for desk or table top use, a new Autograf X-Y recorder features a flat-bed paper table for easy observation and will accommodate standard 11 by 16½-in. graph papers. Recorder may be equipped with curve follower attachment, keyboards, card and tape recorders for laboratory computation, data handling, and production testing applications. It may be modified for digital point plotting. Maximum sensitivity is ½-mv per inch on both axes. Instruments have full-range zero set on each axis, and two independent, servo-actuated, transformer-isolated drives for X and Y axes, and input free of ground. Data can be plotted in any quadrant desired. Size is 23 x 16½ x 8½-in., and weight is 45 lb. **F. L. Moseley Co.,** 409 N. Fair Oaks Ave., Pasadena 3, Calif.

Circle No. **43** *on Reply Card*



Sub-Base for 4-Way Valve

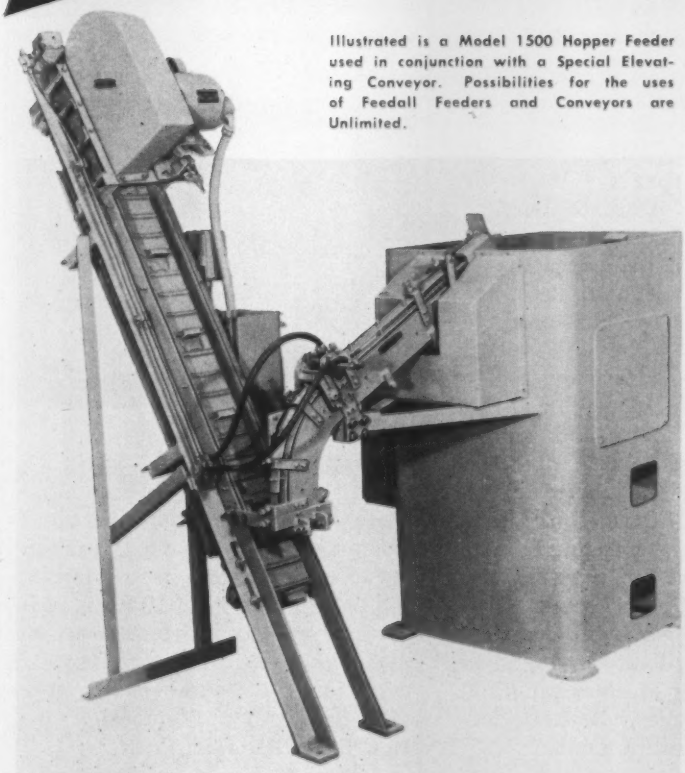
Manifold 4-way, ½-in. valves now can be equipped with a sub-base which provides permanent plumbing and cuts down costly maintenance time in production line. All four lines are brought in from the bottom (Fig. 1), from four sides, or in combination (Fig. 2). When valve needs replacing, the four base bolts are removed in a few minutes and piping remains intact. **Barksdale Valves,** 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle No. **44** *on Reply Card*

Predetermined Productimeter

Control of any electric counting installation to exact quantities required and elimination of over-runs and under-runs is function of a new electrically operated predetermined counter. Device is available in either four or five figures, and is actuated by electric impulses to close or open a switch at any preset count from 1 to 9999, or from 1 to 99,999. Hinged cover gives quick access to wheels for setting. Switch capacity is 5 amp at 125 or 250 v, 60-cycle ac; 0.5 amp at 110 or 200 v dc, non-inductive load; 0.3 amp at 110 or 220 v dc, inductive load. Standard voltage is 105 to 120 v, 60-cycle ac. Coil resistance is 550 to 600 ohms. Counter is completely

Automatic Feeders Speed Production...Reduce Costs



Illustrated is a Model 1500 Hopper Feeder used in conjunction with a Special Elevating Conveyor. Possibilities for the uses of Feedall Feeders and Conveyors are Unlimited.

Consult FEEDALL for Correct Models to Meet Your Needs

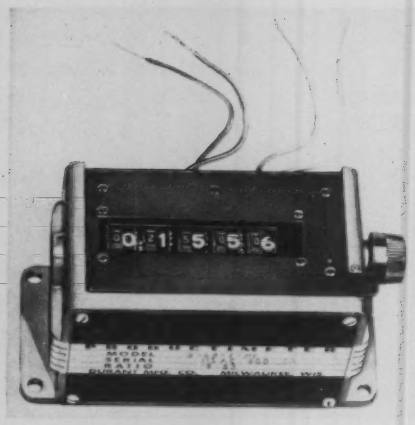
This particular FEEDALL Automatic Hopper Feeder operates with an oscillating blade or center board which picks up the parts and delivers them to the chute. The elevating conveyor positions the parts for feeding into the next automatic machine.

FEEDALL Automatic Feeders are made in many Models with Hopper Feed, Rotary Feed, Vibratory Feed or Blade Feed as may be best suited to the job at hand. All machines are factory tested and are delivered completely assembled, ready to set in position and operate.

Send samples or prints with your production requirements, and we will send you welcome information about FEEDALL Feeders.

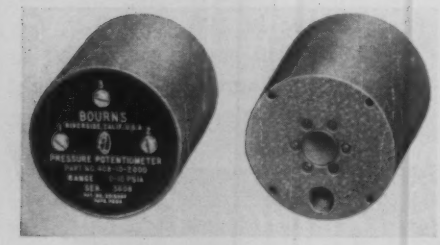
FEEDALL Machine & Engineering Company

38399 PELTON ROAD • BOX 47, WILLOUGHBY, OHIO



enclosed and measures 4⅜ x 2⅛ x 2⅝ in. Applications include electronic computers, nuclear instruments, light production machinery, packaging and tabulating equipment, coil winders, machine tools, and conveyor lines. **Durant Mfg. Co.,** 1997 N. Buffum St., Milwaukee 1, Wis.

Circle No. **45** *on Reply Card*



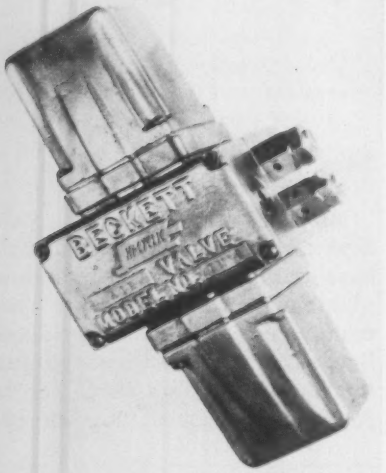
Absolute Pressure Potentiometer

Aneroid type bellows provides absolute reference pressure in a potentiometer designed to measure altitude, fuel pressure, throat pressure, and static pressure in aircraft, missile and industrial applications. Instrument can withstand 50 g longitudinal acceleration with less than 1 per cent error, has resolution of 0.25 to 0.50 per cent for resistances from 1000 to 10,000 ohms. An electrical contact arm with counterbalanced linkage pivots in a miniature ball bearing assembly to provide dependable performance under extreme temperature, shock, vibration, and acceleration conditions. Beryllium copper diaphragm-type bellows insures optimum linearity and repetition with minimum hysteresis and temperature error. Electrical output of ½-w requires no amplification, feeds directly into telemetering transmitters, recorders, or control systems. Instruments can be furnished to meet special electrical specifications. **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.

Circle No. **46** *on Reply Card*

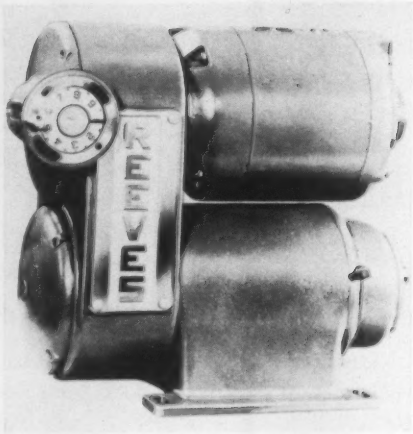
Manifold Mounting Valves

Manifold type Hi-Cyclic operating valves are designed for automation or other control setups where precise control, long valve life and minimum downtime for parts replacement are essential.



Parts are quickly replaced without disturbing piping or main manifold block because of the manifold construction. Electrical models have a built-in junction box and quick disconnect electrical connections so that solenoid coils can be removed without disturbing electrical circuit. All electrical leads are channeled from a ½-in. NPT size conduit outlet at the base of the valve. Three and four-way valves, two or three position, ⅛, ¼, ⅜, or ½-in. nominal sizes, are available for air or noncorrosive gas, and oil or water hydraulics. Actuator can be single or double solenoid (illustrated), pilot, hand lever, fingertip lever, cam roller, or combination. Seal is obtained by precision fit and there are no valve packings. Corrosion resistant materials are used, and those in contact with the medium are bronze and stainless steel. Continuous duty solenoids on electrical valves have resilient bumpers to absorb the shock of energizing and de-energized strokes. **Beckett-Harcum Co.,** Wilmington, Ohio.

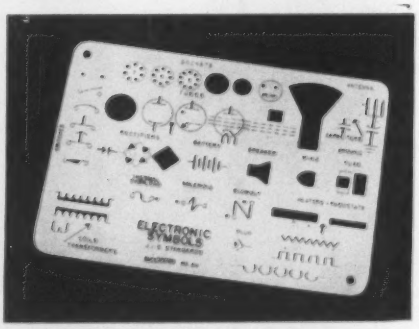
Circle No. **47** *on Reply Card*



Fractional HP Motodrive

Redesigned fractional hp, Varispeed Motodrive is now available in 112 different assemblies to meet exact space requirements. Drive can be had in horizontal, vertical, 45°, and vertical down output shaft models. Unit is available in ¼, 1/3, ½ and ¾-hp sizes, in speed ranges from 2:1 to 10:1, and with output of 3 to 4660 rpm. A threaded, spiral groove lubrication system assures complete lubricant coverage over all sliding surfaces, and overflow outlet carries excess lubricant away from disc faces and V-belt. Standard handwheel, extended handwheel, electric remote and mechanical automatic control are available. **Reeves Pulley Co.,** Columbus, Ind.

Circle No. **48** *on Reply Card*



Electronic Symbol Template

J.I.C. standard symbol cutouts are milled, not punched, for precision smoothness in a template for designers and draftsmen in industrial electronic, television, radio, and electrical fields. Made of 0.030 matte finish plastic, template is 7 x 5-in. **Rapidesign, Inc.,** Box 592, Glendale, Calif.

Circle No. **49** *on Reply Card*

new catalogs..... latest literature

Let us get them for you

Creative Engineering

W. F. and John Barnes Co.—Creative development, design and construction of any specialized mechanical, hydraulic or electrical equipment to individual specifications is company's function, as described in 32-page booklet. Examples of special machine tools, handling and conveying equipment, sorting, counting, assembling and gauging equipment, and electrical controls are illustrated. Booklet includes photos of ordnance plant, said to be close approach to automatic factory of the future, which company designed, built and operated for the government.

Circle No. 50 on Reply Card

Automatic Speed Control

Reeves Pulley Co.—Hydraulic and pneumatic controls, mechanical automatic controls, automatic control to maintain tension of web materials, acceleration controls, Conoflow control (a specialized pneumatic control), differential and electric remote controls can be combined with one of two variable speed units to solve any control problem, according to a 24-page booklet entitled, "Join the Swing to Automation". These combinations of controls and speed units will control tension, acceleration, deceleration, velocity and peripheral speed, will synchronize one or more machines and maintain uniform temperature and pressure.

Circle No. 51 on Reply Card

Plant Modernization

Cross Co.—When, how and why equipment should be replaced is the subject of a 16-page illustrated booklet titled, "How to Get the Most Out of Capital Expenditures". Problems of plant modernization are analyzed, and methods of establishing policies and procedures are outlined. Sample projected plans are submitted in graphic form.

Circle No. 52 on Reply Card

Automatic Storage Handling

Chicago Tramrail Corp.—Automatic cranes and tracks for materials handling utilize maximum storage area and minimize aisle space and labor, as pointed out in bulletin TRC-101. Cranes can be top running or underrunning, will move up, down, forward, reverse, clockwise and counterclockwise. Many examples of operating units are shown.

Circle No. 53 on Reply Card

Flexible Shafting Slide Rule

Stow Mfg. Co.—A slide torque calculator is included with this 12-page bulletin on flexible shafting for power drives and for remote control. Complete data on how to select the correct size and type power drive flexible shaft for any application with a maximum capacity of 1500 lb-in., and data on remote control of flexible shafts with maximum capacity of 4000 lb-in., are given.

Circle No. 54 on Reply Card

Automatic Press Unloading

Sahlin Engineering Co.—A 16-page bulletin discusses and illustrates a line of automatic unloaders, Iron Hands, which are installed on presses and take workpiece directly from the press after stamping. Self-contained unloaders derive their power from their own air cylinders and are independent of press for power.

Circle No. 55 on Reply Card

Hydraulic Components

Hydraulic Press Mfg. Co.—Nine separate catalogs are devoted to distinctly separate components in company's hydraulic line. Each catalog contains all basic data needed by engineer including photos, cross section views, dimensions, operating control diagrams. Subjects of individual catalogs are: pumps, motors, and power units; air and oil hydraulic cylinders (four catalogs); valves and flange connections; valves and gasket mountings; valves and threaded connections; and an engineering manual.

Circle No. 56 on Reply Card

Electronic Computer Elements

George A. Philbrick Researches, Inc.—A revised 8-page catalog of electronic analog computing devices features two series of computing components. K3 series includes integrating, differentiating, adding, coefficient, augmenting integrator, augmenting differentiator, unit-lag, bounding, backlash, inert-zone, squaring, square-root, and absolute-value components. K4 series features dynamic, multiplying, and functional elements. Block equations and diagrams are set up as sample problems.

Circle No. 57 on Reply Card

Precision Machine Tool Attachments

Standard Electrical Tool Co.—Many variations of traverse, slides, feeds, tables, and spindles are offered on a "do-it-yourself" basis to manufacturers who wish to convert old machine tools or to design their own special-purpose tools. Units are available for manual, pneumatic or hydraulic operation. Four-page bulletin illustrates some of the models, and an assortment of grinding machines and attachments.

Circle No. 58 on Reply Card

Selenium Rectifiers

Fansteel Metallurgical Corp.—Well illustrated and diagrammed, this 24-page booklet covers operating principles, installation and care of selenium rectifiers. Typical rectifier circuits, test circuits and characteristic curves are set up as well as charts covering standard cell sizes and ratings, formulae and constants for design engineers.

Circle No. 59 on Reply Card

Cycle-Monitors

Counter & Control Corp.—Engineering data catalog covers a line of circuit controlling preset counters which will count revolutions, strokes, or electric impulses, will transfer a switch when a preset count is reached, hold switch for predetermined count without interrupting counting operation, and return switch to normal position. Cycle repeats automatically, requires no resetting or checking. Installation and operation instructions are included with prices.

Circle No. 60 on Reply Card

Industrial Conveyors

Conveyor Systems, Inc.—Informative 64-page booklet is actually a condensed set of data sheets and illustrations demonstrating applications of various conveyor systems. All types of materials handling equipment are covered including trolley, roller, slat, chain, belt and special apparatus. Overhead, underground, inclined, and turning conveyors with all types of carriers illustrated.

Circle No. 61 on Reply Card

Study of Automating Plants

T. A. B. Engineers, Inc.—An engineering firm has published a concise, 4-page booklet to aid executives in understanding the current significance of automation and in determining whether their factories can be adapted to it. "Cut Costs with Automation" discusses the history and evolution of automation, and contains a check list questionnaire to help evaluate reader's own company, plant and product to determine the practicability there of automation or partial automation.

Circle No. 62 on Reply Card

Central Filter Control

Builders-Providence, Inc.—Control of entire filtering operation is centralized in a system which features semiautomatic or manual sequence backwashing of rapid sand water filters. Control system signals need for backwash according to loss-of-head, carries out wash cycle, and returns filter to operation. Complete details and schematic drawings included in 4-page bulletin.

Circle No. 63 on Reply Card

Power and Speed Control Combination

Dynamatic Div., Eaton Mfg. Co.—Fractional horsepower Adjusto-Spede drives are a combination of ac constant speed induction motors, eddy current couplings, and electronic speed control. Units, engineered to meet specific needs of fractional horsepower drives, are said to have wide speed range, accurate control, low power loss, simple and self-contained construction, and rapid response. Eight-page bulletin covers fundamentals of operation, capacity of available units, mechanical construction features, and control.

Circle No. 64 on Reply Card

Roller Gear Drives for Indexing

Ferguson Machine & Tool Co., Inc.—Roller gear drives for use in precision indexing of automatic production machinery are described in a 24-page catalog. Drives may be applied to dial, carrier chain, feed roll or oscillating indexing systems. Catalog discusses selection of drive, calculation of load requirement (illustrated by sample problems), designing of installation, and detailed instructions on how to order a drive unit. Complete tables on load rating and on dimensions for entire drive unit or components, as well as price lists and estimate sheets, are attached.

Circle No. 65 on Reply Card

(Continued on back side)

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Machine Tool Fixtures

Swartz Tool Products Co.—"Advancing Automation" is title of a new 8-page bulletin describing company's complete services to builders of machine tools, and its facilities for the design and construction of precision work-holding fixtures. Typical fixtures for standard, single station, rotary index, trunnion index, and transfer machines are illustrated with factual data on each.

Circle No. 66 on Reply Card

Cylindrical Grinding Handbook

Landis Tool Co.—A comprehensive 36-page handbook is offered on precision cylindrical grinding. Complete data on grinders and wheels, their operation and maintenance, are demonstrated with illustrations, sketches, charts and tables. A table of grinding wheel speeds, a chapter on common grinding troubles and how to correct them, and a list of safety suggestions are particularly valuable. This handbook is recommended for operating executives, engineers, supervisors, operators and apprentices.

Circle No. 67 on Reply Card

Automatic Spray for Die Press

Hamilton Automation Inc.—Die presses can be equipped with an automatic spray unit which will spray compound automatically at each press stroke in metered amounts to critical locations. Press need not be stopped to spread compound on lower part of the die, compound is not wasted, and die life is increased. Folder is available describing unit and components.

Circle No. 68 on Reply Card

Automation In Industry

Associated Metal Fabricators, Jersey Sheet Metal Products, Inc.—"Custom Fabricating for Industry" is a study of increasing production efficiency and lowering costs through automation. Latest production line techniques are demonstrated by a selection of mechanized equipment designed for special use in industry. In addition, booklet covers industrial ovens, tanks, winding and racking equipment, and special heavy duty metal working machines.

Circle No. 69 on Reply Card

"Dag" Colloidal Dispersions

Acheson Colloids Co.—Twelve-page general catalog contains comparative table on 40 basic dispersions of graphite, molybdenum, disulfide, vermiculite, and zinc oxide in carriers such as water, oil, volatile hydrocarbons, resin solutions, alcohol, glycol, and wax emulsions. Information also specifies 108 particular products and processes aided by dispersions.

Circle No. 70 on Reply Card

Pressure Control Valve

Minneapolis-Honeywell Regulator Co. — A pressure balanced diaphragm motor valve designed for accuracy and speed of response in pressure control is subject of specification sheet 425. Valve is springless, double-seated, with downstream take-off connected back to lower pressure chamber of the top works. Providing highly sensitive control of outlet pressure, valve handles liquids or gases, is particularly applicable to pressure reduction of fuel in jet engine test cell fuel lines. Specifications, mounting dimensions and ordering information included.

Circle No. 71 on Reply Card

Grinding Coolant Filtration

Industrial Filtration Div., U. S. Hoffman Machinery Corp.—Packaged units are used in finish grinding of ferrous metals where grit and metallic particles are small and coolant must be exceptionally clear. Throwaway cartridges and magnetic plates are combined to do the filtering at flow rates of 20 to 40 gpm. According to descriptive data sheet, the unit can handle both mineral oils and water soluble coolants.

Circle No. 72 on Reply Card

Rotary Tables for Indexing, Milling

W. E. Knight Machinery Co.—Power feed rotary tables suitable for rotary milling and indexing, automatic cycle milling and indexing, and continuous face milling have infinitely variable feed drive controlled by limit switches. Eight-page bulletin illustrates and describes the two models, a 20-in. table and a 42-in. version which can be increased to 72-in. diameter with the use of subplates. Sectional views, diagrams, and specifications included.

Circle No. 73 on Reply Card

Operating and Maintaining Unloaders

Sahlin Engineering Co.—Eight-page bulletin for owners or prospective owners of Iron Hand unloading machines provides simple operating, mounting, wiring and lubricating instructions for the units. Wiring and airline diagrams are included as well as parts lists for reordering and specifications for gripping jaw assemblies.

Circle No. 74 on Reply Card

Variable Speed Drive and Control

U. S. Electrical Motors Inc.—An automatic drive and control for use in operations involving variables such as temperature, pressure, speed, liquid level, weight, tension, and position are known as Varidrive and Varitrol. Four-page bulletin gives operating data and applications which include program and machine tooling control. Varitrol is basically a pneumatic amplifier composed of a power and a signal system. High pressure power system operates piston in the cylinder, is controlled by a low pressure signal system. Drives are available from ¼ to 30 hp with speeds from 14 to 14,000 rpm.

Circle No. 75 on Reply Card

Hydraulic and Air Cylinders

Hanna Engineering Works — New line of fluid power cylinders features large capacity to size ratio, corrosion resistance, minimum friction, interchangeable components, positive cushioning, air operation up to 250 psi, and hydraulic operation up to 750 psi. Capacity charts, mounting installations, dimensions, and accessories are set forth in a 14-page catalog, as well as a check list of considerations to be taken in cylinder application and ordering specifications.

Circle No. 76 on Reply Card

Grinding Wheel Spindle Bearings

Cincinnati Milling Machine Co. — Filmatic spindle bearings for grinding wheel provide both self-adjusting rigidity and low friction for grinding operations. Automatic lubrication and cutout switch stops spindle drive motor in case of oil failure and contributes to long life. Heavy roughing operations and ultrafine surface finishing are available on the same machine without bearing adjustment. Colorful 16-page booklet presents "X-Ray" illustrations of unit in operation.

Circle No. 77 on Reply Card

Instrument Control for Hopper Scale

Richardson Scale Co.—A complete weighing, indicating and recording cycle is described in booklet on instrument system for use with hopper scales. System features interlocking switches, time delay before full balance printing, partial draft printing, follower dial accuracy, and dust control provisions. Dimensional engineering drawing and table listing headroom requirements for hopper scale included.

Circle No. 78 on Reply Card

Vari-Speed Motor Pulleys

Reeves Pulley Co.—Engineered for use with new NEMA frame motors and adaptable to the old NEMA motors, a redesigned line of Vari-speed motor pulleys is available in eight sizes from ½ to 15 hp, in speed ratios up to 4:1. Smaller disk assemblies and threaded spiral groove lubrication for rustfree operation are among new features described in a 28-page catalog. Description, construction details, lubrication, available controls, selection instructions, rating tables and dimensional diagrams included.

Circle No. 79 on Reply Card

Windowless Flow Counter

Atomic Instrument Co.—Counting of alpha and beta particles in solid samples, and geiger and proportional counting are primary functions of a new windowless flow counter described in Bulletin 952. Rapid changeover of samples, gas-tight chamber, and counting rates independent of variations in gas flow are featured.

Circle No. 80 on Reply Card

Automatic Washer for Castings

International Conveyor & Washer Corp.—An automatic indexing, fixture type, three stage industrial washing machine processes 400 castings per hour, externally and internally, and maintains cleanliness of solutions automatically. Four-page bulletin describes machine and its components, complete cleaning cycle, and gives specifications.

Circle No. 81 on Reply Card

Water Filtration Instruments

Builders-Providence, Inc.—"Instrumentation and Control for Water Filtration Plants", a 16-page bulletin, deals with complete line of equipment for water treatment plants. Publication gives technical descriptions and illustrations of meter instruments, filter effluent rate controllers, wash water controllers, filter gages, wash water gages, flow summa-

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tion, sand expansion gages, gage dials, filter operating tables, control panels, automatic operation of filters, level gages, basin level controls, plant controls, filter underdrains, chlorinizers.

Circle No. **82** *on Reply Card*

Pressure Measurement

Statham Laboratories, Inc. — Transducers based on principle of strain gage will translate pressure into an exact electrical analog output by means of a complete balanced bridge of strain-sensitive resistance wire. Complete line of these instruments for measuring gage, differential and absolute pressures is described in a 12-page bulletin which includes drawings, specifications and selection tables.

Circle No. **83** *on Reply Card*

Oxygen Control in Kiln Operation

Arnold O. Beckman, Inc.—Advantages of regulating air when firing ceramic products are listed in bulletin entitled, "Industrial Gas Analysis in Tunnel Kilns". These include proper burning of carbon out of the ware, reduction in number of rejects due to coring, and increased production profits through consistently high quality ware. Typical installation is illustrated and necessary sampling and analysis equipment is listed.

Circle No. **84** *on Reply Card*

Precision Potentiometers for Servos

Helipot Corp., Beckman Instruments, Inc.—"Characteristics of Precision Servo Computer Potentiometers" discusses linearity in detail, and sets forth data on research, developments, and trends in precision potentiometers as voltage dividers. Twelve-page technical paper is illustrated with graphs and diagrams.

Circle No. **85** *on Reply Card*

Catalog of Mining Tools

Carboloy Dept., General Electric Co.—Mining tool and accessory catalog lists cutter bits, finger bits, auger drills, roof bolting drills, auger steel, grinding wheels, masonry drills, jackbits and stone cutting tools. Design specifications included with listings in 18 pages.

Circle No. **86** *on Reply Card*

Automated Machine Tools

Turchan Follower Machine Co.—Three automation systems offered by company are (1) automatic control systems for machine tools already in use, (2) entirely new servo controlled machine tools, and (3) servo control systems built into products of major machine tool manufacturers at their plant. Well illustrated and diagrammed 24-page booklet discusses principles of automation, shows typical control applications, and features two specialized tracer-controlled machines now in production—the hydro-router for production routing and milling, and the vertical contouring lathe for reproducing irregular contours.

Circle No. **87** *on Reply Card*

INDEX OF ITEM NUMBERS BY PRODUCTS

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Vibration Elimination

International Research & Development Corp.—"Balance—Final Dimension of Precision" is the title of a 16-page booklet which discusses the relationship between vibration phenomena and precision manufacturing. Descriptions and illustrations of vibration analysis equipment demonstrate how analyzers eliminate unwanted vibration in rotating parts.

Circle No. **88** *on Reply Card*

Capsulated Precision Resistors

Ohmite Mfg. Co.—Data sheet contains specifications of precision, wire wound resistors in ¼, 1/3, ½, ¾, and 1-w sizes which are capsulated in a special resin and have resistance wire welded to terminals. Individual and grouped units, containing several individual units in one molded resin body, are discussed. Resistance values, wattages, voltage ratings, and dimensional drawings included.

Circle No. **89** *on Reply Card*

Pneumatic Controllers

Fischer & Porter Co.—Stack type pneumatic controllers, for process variables such as flow rate, liquid level, viscosity, pressure, temperature, and vacuum, are illustrated with cutaway photographs, schematic diagrams, and dimensional drawings in a 12-page catalog. Specifications, controller selection guide, controller response actions, and accessories are included. Units can be case, field, or valve mounted.

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FOR EDITORIAL CLIPSHEETS (Circle page number below)

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MORE INFORMATION ON ADVERTISED PRODUCTS

Circle page number. Key: IFC—Inside front cover, IBC—Inside back cover, OBC—Outside back cover, L—left, R—right, T—top, B—bottom.

IFC	6-7	73	83	103	109TR	112TL
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New Catalogs & Literature

Heavy Duty Limit Switch

R. B. Denison Mfg. Co.—Long lasting switch has "bounce" characteristics of a light duty switch and vibration resistance of a heavy duty switch. Single pole, double throw, double break switch has trigger type actuator, is said to be the most easily maintained switch on the market. Complete specifications and cutaway illustrations shown in a 4-page bulletin.

Circle No. **91** *on Reply Card*

Vibrating Conveyors

Hewitt-Robins Inc.—Well illustrated booklet describes a line of vibrating conveyors that will handle hot or cold, wet or dry, pulverized or lump, packaged or loose materials. Running on relatively low horsepower, these units remain constant under heavy fluctuating loads, level out batch feeds, can be installed as double deckers with top level used as work table.

Circle No. **92** *on Reply Card*

Design of Saturating Servomechanisms

Cook Electric Co.—A 16-page booklet entitled, "Design Considerations of a Saturating Servomechanism" takes general principles underlying multiple mode control of servomechanisms and determines optimum values with which the designer can synthesize a saturating linear servo system that will have a response approaching that of the optimumly switched servo. Relationship between saturated and unsaturated regions is shown, and method whereby the effects of torque and velocity saturation can be considered when choosing the linear parameters. Effects of various damping factors upon the saturating response are described by phase plane analysis. Phase plane allows determination of optimum response of system for a given motor and load.

Circle No. **93** *on Reply Card*

Automation Timers

Eagle Signal Corp.—Application of timers in design and function of machines for automatically handling, machining or processing parts and materials is discussed in a 12-page illustrated booklet. Timers are discussed in two categories, reset or repeating cycle. Seventeen specific models are treated in detail.

Circle No. **94** *on Reply Card*

Record Playback Control

General Electric Co.—Illustrated 6-page bulletin describes system of recording motion on magnetic tape and playing it back for automatic programming of production machines. Recording is taken by selsyns (synchros) coupled to feed motors to report motors' angular positions to tape by electrical signals. Recording can be taken of operator's manual operation of machine, or, for more complex parts, of motion of a tracer head. Still in planning stages are recording systems taken from line drawings requiring no machine setup, and operation from digital information which will be punched on paper tape.

Circle No. **95** *on Reply Card*

Data Handling by Punched Cards

Remington Rand Inc.—Multi-control reproducing punch uses punched card procedure for descriptions, analyses and breakdowns, extending and computing, searching and sorting, verifying, comparing, correcting, reproducing and interfiling data. Six-page bulletin illustrates procedure, which will handle 6000 to 12,000 cards per hour, and recommends it for production control, payroll and tax accounting, billing, and statistics preparation.

Circle No. **96** *on Reply Card*

Management Engineering

Alden Elstrom Associates—"What We Do For You" is an 8-page pamphlet published by a firm of consulting engineers, describing company's services which include consultation in management, production, industrial, and business engineering. Automatic plant layouts, design and installation of incentive systems, production and quality control illustrate the variety of services offered.

Circle No. **97** *on Reply Card*

ElectroniK Null Indicator

Minneapolis-Honeywell Regulator Co.—ElectroniK null-balance detector is unaffected by vibration and requires no special mounting or leveling, eliminating disadvantages of conventional suspension galvanometers. Specifications and performance, said to be fastest possible for resistance, and potential measurement with null-balance indicators, are outlined on data sheet 10.0-12.

Circle No. **98** *on Reply Card*

Electrical Panel Instruments

DeJur-Amsco Corp. — Available in round, square, and rectangular models, a line of standard range electrical indicating instruments is specifically designed to meet ASA requirements. Four-page bulletin gives details and illustrates various models of these panel instruments.

Circle No. **99** *on Reply Card*

Industrial Waste Treatment

Graver Water Conditioning Co.—Four-page bulletin points up advantages inherent in treatment of industrial waste waters and process liquors—(1) prevention of stream pollution, (2) acquisition of reuseable water, and (3) recovery of materials and heat. Four case histories, including schematic diagrams of systems installed, are taken from metal plating, petroleum, paper, and general industry to illustrate how company's equipment solves waste problem.

Circle No. **100** *on Reply Card*

Positioning for Radial Drills

Fosdick Machine Tool Co.—Automatic positioning table, available for use on radial drills, is described in a 4-page bulletin. Table employs two simple duplicating bars to give automatic and exact reproduction of precision drilled, bored, tapped and reamed parts without use of jigs or stop adjustments. Automatic positioning of work by pushbutton is held to a tolerance of $\pm$0.0001-in. Bars provide permanent record of each particular job.

Circle No. **101** *on Reply Card*

Vibration and Shock Mountings

Robinson Aviation Inc.—Resilient, primary load-carrying cushions of knitted metal wire, called Met-L-Flex, form basis of new vibration and shock control. Four-page bulletin shows how units will stop vibration, eliminate shock, and reduce noise, in addition to illustrating typical mounting systems complete with engineering data. Mountings are recommended for delicate precision instruments, motors, engine mountings, large machine tools, press drives and drop hammers.

Circle No. **102** *on Reply Card*

Duplex Vertical Broaching Machine

Cincinnati Milling Machine Co.—Twelve-page catalog on a duplex vertical hydrobroach machine contains illustrations of applications, dimensional drawings, and specifications. Features of machine are the twin horizontal tables which automatically recede and advance in synchronization with twin vertical rams, cutting and returning simultaneously. Pressure lubrication is automatic and preset cycle control a safety feature.

Circle No. **103** *on Reply Card*

Environmental Testing

New York Testing Laboratories, Inc.—Informative 4-page bulletin describes company's service of environmental testing for vibration, shock, acceleration, high and low temperature, temperature shock, humidity, high altitude, explosion, salt spray, sand and dust, and fungus. Some of the testing equipment is illustrated, and all tests are described in terms of equipment used and its capacity range.

Circle No. **104** *on Reply Card*

Automatic Precision Tapping

Automatic Methods Inc. — "Auto-Tap", a lead screw tapping attachment which converts any standard 14 to 20-in. drill press into a precision tapping machine and at the same time eliminates the need for a skilled operator, is described in detail in a 4-page bulletin. Order blank and price lists attached.

Circle No. **105** *on Reply Card*

Flexible Shafts and Couplings

Kupfrian Mfg. Co.—Technical catalog lists 16 pages of flexible shafts and couplings with full size dimensional drawings of more than 30 couplings and assemblies, and more than 100 terminal fittings, casing ferrules and nuts. Data on design and use of shafts and couplings are followed by practical tables of physical properties of shafts and shaft casings.

Circle No. **106** *on Reply Card*

Grinding Coolant

Motch & Merryweather Machinery Co.—Triple C grinding coolant for all wet grinding applications is described in a data sheet. Name derives from coolant's outstanding characteristics: clear because transparent solution makes progress of work clearly visible; cool because heat is dissipated; clean because chips and grinding dust flush and settle quickly, and because coolant can be thrown into streams without danger of contamination.

Circle No. **107** *on Reply Card*

Electrical Contact Rivet Slide Chart

Fansteel Metallurgical Corp.—A copyrighted slide chart is available to facilitate selection of solid or composite rivet type electrical contacts. Maximum and minimum dimensions for head thickness, shank diameter, and shank length for a given rivet head diameter can be determined for rapid and economic production of contact rivets on automatic heading machines.

Circle No. **108** *on Reply Card*

Relays

Magnecraft Electric Co.—Complete line of relays, including long and short form telephone type, sub-miniature, latching and low capacitance, and open, plug-in, hermetically sealed relays, is described with engineering and dimensional data in new catalog.

Circle No. **109** *on Reply Card*

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AUTOMATION

ABSTRACTS

FOUNDRY AUTOMATION BY SHELL MOLDING

By J. L. BISHOP
Vice President and Director of Engineering
Mechanical Handling Systems, Inc.
Detroit, Mich.

BASIC PRINCIPLE of shell molding is so simple that foundrymen, factorymen, and engineers have been wondering since they heard about it, just why the idea hadn't occurred to them. The mechanics of shell molding involve simply the application of a mixture of sand and resin on a heated pattern plate. The heat melts the resin, the resin binds the sand into a smooth mold. Then a matched pair of these molds is held together and molten metal is poured into them in the proper quantity. The casting is allowed to cool, after which it is removed from the mold.

Advantages of Shell Molding

A powerful influence for quiet development was the potential competitive advantage that might accrue to the successful pioneer in shell molding. Production of the molds is simplified. It is a mechanical process, accomplished by a machine and requiring only an unskilled operator. One low-rated worker using shell molding equipment can out-produce several highly skilled and highly paid green sand mold makers. The molds produced by the unskilled operator and his machine are very much more accurate molds than those made by conventional methods. They have smooth, dense surfaces, yet they allow free passages of gas when the metal is poured, thus preventing blow holes and defects caused by gas. The castings produced by the shell molding process have remarkably close tolerances. Accuracy within a few thousandths of an inch is easily attained, and the surface of the castings is so fine that finish machining is either unnecessary or is held to a bare minimum. Shell molds are from $\frac{1}{8}$ to $\frac{3}{8}$-inch thick, and weigh only a fraction as much as a conventional mold. The lightness of the molds makes a tremendous difference throughout the foundry by reducing the material handling load per pound of casting produced.

Only an automatic shell mold making machine, capable of producing hundreds of high-quality molds per hour, could furnish the basis for sound and complete mechanization of a shell mold foundry, utilizing many of the automatic production principles which have been proved in other industries.

The machine shown in *Fig.* 1 revolves counterclockwise, with the shell removal station at the far left as the end of the cycle. Each of the 12 stations produces a shell mold with each complete revolution of the machine. There can be 12

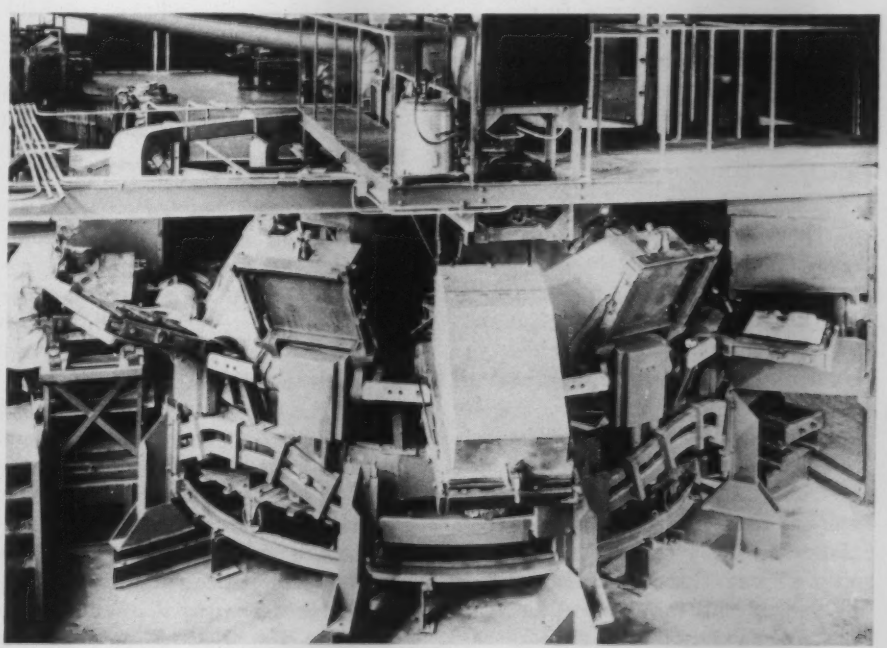

Fig. 1—Twelve-station shell molding machine, automatic from materials blending to the completed mold. Production, 500 molds per hour

identical patterns on the machine, or 12 different patterns, or any variation in between. Patterns may be changed at any time, without halting production.

The pattern, after it leaves the shell removal station, rises to engage its hopper. As it progresses, pattern and hopper descend to below the horizontal, and the sand-resin mixture drops onto the pattern. Then the pattern and hopper rise, excess sand drops into the hopper, the pattern is disengaged automatically, and returns to the horizontal. Pattern and raw shell mold now enter an oven, are held to the proper temperature by radiant gas-fired burners, and the mold is cured. During the pattern's movement through the oven, its corresponding hopper is replenished automatically as it passes under the sand-resin supply point.

When the cured mold emerges from the oven, its ejection pins are raised by means of cams which engage rails placed at the discharge station, and the mold is lifted off the pattern and is easily removed, either by hand, or by an automatic transfer device.

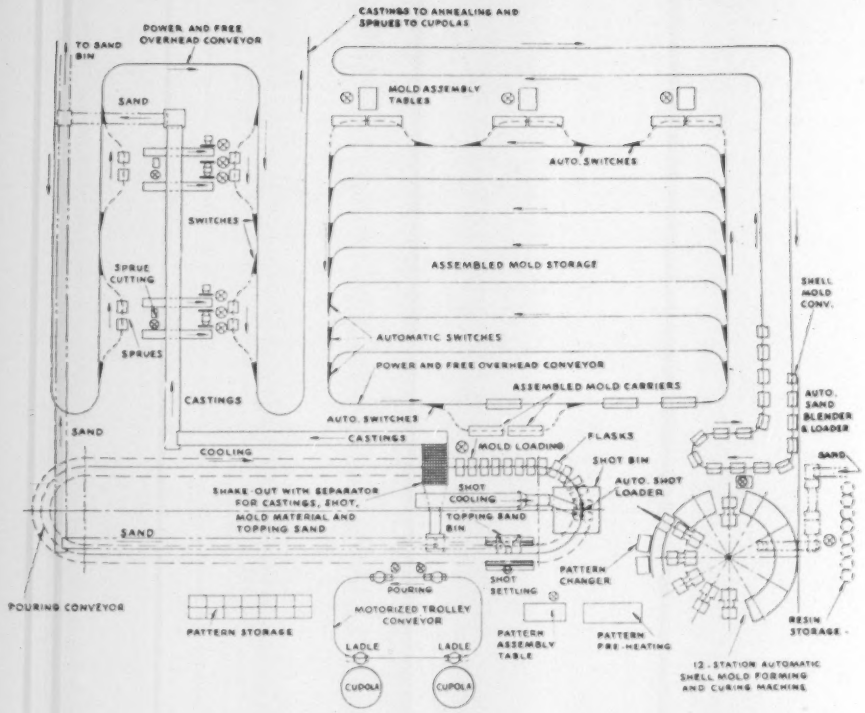

Fig. 2—Mechanized shell mold foundry, with 12-station machine, can produce 1920 molds per 8-hour shift, or about 50 tons of small castings

The Automatic Shell Molding Foundry

With automatic shell mold making machinery available as the starting point, the fully automatic shell molding foundry can now be designed, *Fig.* 2.

A standard overhead conveyor is synchronized with the shell mold machine so that each station on the machine delivers molds to the carriers designated to receive that particular type of mold. Station No. 1 delivers molds to No. 1 carriers; station No. 2 molds go on No. 2 carriers, etc. Thus the conveyor separates and classifies the shell molds in a simple, logical, easy way.

The overhead conveyor takes the molds to the three mold assembly and core placement benches, where workmen remove the molds from the conveyor, put the cores in position, clip or glue the cope and drag halves of the mold together, and place the assembled molds on carriers of the storage and delivery conveyor.

The storage and delivery line is a power and free conveyor. This type has a "mainline" which is powered, and spur or switch tracks on which the carriers are freed of the power source. Automatic switches are a part of the power and free system, as well as automatic controls which can be preset to take a carrier to a designated spot in the system—say a loading station or a particular storage line.

Empty carriers are automatically switched onto free stations at the mold assemblers' benches and are loaded with completed molds of a single type. Loaded carriers are dispatched, under automatic control, to the proper storage line—No. 1 molds to No. 1 storage line, and so forth—where they wait until they are required by the production schedule.

At the discharge end of each storage line there is a switch and an indexing bar, actuated by the man who assembles the molds in flasks on the casting conveyor. When he wants No. 1 molds he pushes a button which acutuates the indexing bar at the end of storage line No. 1. The indexing bar moves a carrier loaded with No. 1 molds through the automatic switch onto the power line which carries it around and shunts it automatically onto a free section at the flask loading station.

With this system, it is a simple thing to follow a production schedule exactly, pulling molds from storage in the exact order and quantity desired. Meanwhile, the mold making machine, back at the start of operation, is working at its most efficient rate of production, keeping the bank of assembled molds replenished.

The operator at the flask loading station places molds in flasks as they move past him on a plate-type conveyor running parallel with the power and free line. Then, as the flasks move on, an automatic device releases shot backing around the molds. The flasks then pass an operator who inspects them, adds shot protective material and removes the plug from the pouring spout of each mold.

Only two men are required for metal supply and pouring in this foundry. A powered monorail loop brings ladles of molten metal from the cupolas to the pouring station, which is a platform conveyor moving at exactly the same rate of speed as the flask conveyor. Pouring is easy, quick and sure in this

synchronized operation.

During the rest of the circuit on the flask conveyor, the castings are cooling. Then, at the shakeout point, flasks are automatically removed and their contents of castings, shot and sand are separated.

Shot goes by its own conveyor to the shot hopper near the flask loading point, where it is automatically cleaned and cooled before re-use.

Sand drops down onto a belt conveyor and it, too, is cleaned and reconditioned and returned to the sand bin.

Castings are discharged onto a cooling conveyor which delivers them to sprue removal. Castings are classified here and are placed on carriers waiting on the free line of a second power and free conveyor. When they are loaded, the carriers are switched to the power line and dispatched automatically to finishing or storage. This power and free line also carries sprues to metal storage.

The automatic shell molding foundry just described requires only 15 or 16 men for the whole operation. Not a single job in the plant calls for a high degree of skill, or for long training. Since machines and conveyors set the rhythm of production, this automatic foundry requires a minimum of supervisory time, yet the standards of work accomplished will be easily met through shift after shift.

From a paper entitled, "Automation of shell Molding" presented at the Annual Meeting of ASTE in Philadelphia, Apr. 1954.

TRANSFER MACHINE PLANNING

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DURING the last twenty years, the transfer machine has developed from the original one- and two-station, hand-clamped and hand-transferred drilling machine to the 20-station, or larger, completely automatic machine performing a wide variety of operations. That this type of machine has been accepted by industry is proved in the automotive industry which in the past six years had introduced a number of new V-8 engines. Without exception, the major units of these engines are now processed on transfer-type machines. These units include cylinder blocks, cylinder heads, chain cases, bearing caps, and manifolds. Such wide acceptance and use should be proof enough that the transfer machine in today's highly competitive market is as much of a necessity as the multiple-spindle head became in the 1920's.

In discussing how to plan a transfer machine we do not propose to talk about any definite method of approach to the problem. Methods of planning will vary with each man. We would rather point out the many important points which will affect the finished installation.

Proper planning should start in the sales engineering department where a careful study of the workpiece should provide a routing that will exploit the advantages of the transfer type machine. Obviously the most important advantage is the opportunity to add machining passes without increasing the number of operators. Each operation should be checked against the required production rate, by carefully taking into consideration tool loads, and the number of passes required for each operation will be determined. While adding passes to obtain the required production is important, an equally important advantage is the opportunity to break up difficult operations into more simple ones. For instance, close-center spindles and combination tools can be eliminated and, where accuracy or finish demands, additional passes on surfaces or holes can be provided.

When close-center spindles are eliminated, a much superior head design can be used with simple gear trains and large anti-friction bearings on all spindles. This point is emphasized by some customers who arbitrarily set up rules stating that drill spindle centers under 2¼-in. are not acceptable. Rules of this sort point out maintenance problems experienced on previous machines where the machine tool builder, under competition, added spindles on close centers to eliminate a second machine.

The advantage of taking additional passes at surfaces and holes to better the accuracy of the finished part is very important. For example, valve lifter holes in an overhead valve engine have always posed a problem in accuracy. Transfer machines have bettered previous conditions by the following sequence of operations:

1. Drill the clearance hole through the cylinder head face, and spot drill the valve lifter boss.
2. Drill the valve lifter hole through.
3. End-cut bore.
4. Semifinish ream.
5. Finish ream.

All of the tools in this operation are carried in precision stub spindles working on every other hole to give sufficient center distance and provide for simpler design. Inspection gages in one plant show that diameters are held to total tolerance of 0.0005 inch.

Machine Arrangement

At the sales engineering stage, dimensions of the machine proper should be established. The transfer distance between stations must be studied carefully, since it is a dimension which will provide ample room around the working units and fixtures for service and tool changing. An engine block machine may be designed with a transfer distance of 50 in., to attain accessibility of the working units and fixtures. In addition, idle stations may be provided for visual inspection of the block and to further spread the distance between the stations, providing room for maintenance and allowing the use of units and bases large enough to properly support the working tools. We have listed this

opportunity to provide ample room as an advantage, since it is a characteristic of the transfer machine; but strangely enough it is one that is often neglected.

By providing handling or turnover fixtures in the line, the work piece can be properly positioned for each operation. This is an important advantage, eliminating lower angular and inverted heads and allowing the combining of operations in the proper sequence. For instance, all of the tapping of the cylinder block is combined into one machine concentrating the use of coolant into one area. This is made possible by turn fixtures at the appropriate stations.

Checking devices of various types, placed in the line following critical operations, give 100 per cent inspection and prevent the line from filling up with parts which should be scrapped or which will require salvage operations. These devices can vary from exacting air gages to simple arrangements for checking the depth of drilled holes.

Difficulties to Consider

If the part is irregular in shape and without suitable holes and surfaces, it may be necessary that it be located and clamped to a transfer plate. This plate would be complete with hardened and ground locating and transferring surfaces and fitted with bushing for locating in each station. This type of machine was used extensively during World War II for machining radial piston engine cylinder heads.

Another disadvantage which must be considered is the condition existing where chips and heat created in one station may affect following stations and operations. For instance, where blind holes are to be tapped or reamed, dumping fixtures or blow-out stations to clear chips should be added following the drilling stations.

Roughing operations, which would tend to introduce heat and distortion into the work piece, should be separated from finishing operations which could be affected. Of course, on a part where a number of transfer machines are required, it is common to arrange all roughing operations into the first machines in the line, with the finishing operations in the later machines.

Customer Co-ordination

Immediately following the sale, a very important phase of planning is necessary before actual design can be started. It is the opportunity to work closely with the customer, planning details of the installation. Foundations, chip and coolant systems must be fitted into the plant layout to the best advantage. If automation is to be used, the machine-handling equipment must be coordinated with the machine preceding and the one following. This automation can either be a separate unit handling the parts between machines, or the machine transfer bars can be so interlocked that they remove parts from a common bank station at the front of the machine and deliver them to another bank station at the rear end.

Clearing fixtures and locating surfaces of chips is one of the most difficult problems facing the designer. He must carefully consider the location and size of locating pads and positively see that chips do not permanently lodge on them. Mechanical devices for removing chips from the machine proper are used almost universally, but it is the designer's responsibility to see that the chips reach the conveyor; otherwise, the advantages are lost.

It is essential that some type of automatic lubrication be provided in these machines. These systems insure a measured amount of oil to each important wear surface at a predetermined interval of time. To attempt to lubricate properly with the obsolete method of hand oiling on machines of such size would be impossible. Similarly, where coolant is used, automatic filtration systems keep supply lines free of chips, improve the quality of work, and simplify maintenance.

Summing up, a complete careful study of the workpiece and the proper planning of the necessary

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transfer machine will insure the following for the customer: His transfer machine will provide the number of machining passes necessary to maintain production and quality without complicated or overloaded tooling, and trouble-free handling with a minimum of operators and maintenance. It will be a good tool and will help to make more things, both necessities and luxuries, available at lower cost to more people.

From a paper entitled "How to Plan a Transfer Machine" presented at the Annual Meeting of ASTE in Philadelphia, April 1954.

PLANT LAYOUT

by H. H. Dasey
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TOP MANAGEMENT today is becoming deeply concerned with the shortcomings and confusion existing in plant layout techniques. In a widely organized and engineered industrial economy such as ours, it seems strange that our great emphasis on standardization of procedures has more or less been ignored in one of the most important phases of this industrial economy.

Space - composition breakdown for manufacturing follows a mathematically determined course, based on:

1. Type of product manufactured.
2. Material from which it must be processed.
3. Methods through which it will be manufactured.
4. Types of equipment necessary to its manufacture.

Type of product will, to a major degree, determine the overall space requirements of the plant. The layout and planning group, armed with information as to type of product and material to be used, is faced with the job of composing the manufacturing space or layout. Questions are: "How much space will be needed for incoming material?"; "How will it be handled?"; "What are the storage conditions necessary to its proper care, i.e., moisture, dryness, temperature, etc?"

Quantities of this incoming material are dependent on the amount of units to be produced. Other factors include distance which material is to be shipped and the delivery time required, and also the availability of the material itself in the open market. For instance, it will be necessary to carry a greater on-the-ground stock of materials which are spotty in supply, hard to get because of rigid specifications, or whose source is so far removed from the plant that large stockpiling is necessary.

Next comes the manufacturing space requirement where the actual production elements "chew up" this raw material and produce a fabricated or finished product. If the operation sequence has been broken down sufficiently, either through experience or through extremely good planning, the number of machines or pieces of equipment necessary to properly process the material can be very accurately determined.

Many things determine the amounts of space allocated to each machine or each part of the processing effort. Space requirements are different if material and parts in process are handled on hand trucks or on skids with towmotors. If the manufacturing area is completely conveyorized to such an extent that truck handling is not required except in few instances, actual manufacturing space can be reduced substantially.

Flow Through the Plant

Handling of materials and parts in process is the most important single operation in the plant. Duplication of handling or wasteful handling techniques can result in costs as high as 35 per cent of the total cost of the manufactured product. It is only recently that industry in general has become conscious of this fact, and is now concentrating considerable attention toward reducing these costs.

Not all plants move material on the floor, a great many of them use overhead equipment. Much of

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this equipment is suspended from the building structure, usually the roof truss or the floor girders of upper floors. There have been cases where maintenance men have hung monorails from roof trusses and collapsed the roof, because the building was never planned to take such loading. Actually, it costs very little more to strengthen building structures to take the added loads superimposed by material handling equipment, if this is incorporated into the original design. If the material handling manager will advise the planning engineer of anticipated installations, a very efficient and functional building design is possible, practical, and much lower in cost than a patched-up job later.

How will the product of the plant be shipped to customers? By rail, common carrier truck, customers' truck, parcel post, air freight, water? How much of each? Are packing facilities required? What kind? Is a box shop required? Lumber storage? Carton storage? Will palletized loads be handled? Will depressed docks be needed? Crane service? Conveyors? Is a temporary warehouse needed for building up loads? What rail connections will the plant require? How much spur or siding? Will it be necessary to load or unload cars out of the weather? Should cars be in a depressed well? Are crane facilities required? How many cars must be spotted at one time? What size of cars will be handled? Will spotting or shifting be required by other than railroad crews?

Machine Tools Only Part

This brief look at the complex mechanical requirements will indicate the job facing the layout engineer, whose responsibility is not only to determine the answer to these mechanical questions but also to produce a proposed layout for approval in such a manner or method that these answers will be illustrated clearly, concisely and require no translation. Thus arises the problem: What type of layout will encompass these facts best?

You cannot plan a plant or make an intelligent layout with machine tools alone.

First, machines in themselves rarely account for more than 20 per cent of the total floor space in any plant. Check this in your own plant.

Secondly, the layout problem so far as machines are concerned is determined by their relationship to the product manufactured. This relationship is mathematically determined by the product, the number and types of operations to be performed on it, and the rate at which it is to be produced. Thus, the progression and order of the individual machine operation, such as grind, bore, drill, tap, etc., are easily established. This basic processing order, however, constitutes only a minor and supplementary step in planning the layout. It merely determines the order in which the machine operations will occur.

Thirdly, you cannot plan a layout with machines alone, because the principal problem in developing any layout is movement, and machines do not move; they go nowhere but simply sit in a predetermined spot and chew up materials or parts in process as they are fed. It is the activity the machines create in chewing up or processing material that presents the basic layout problem. Therefore, layout is not a matter of placing a relatively few machines, but rather it is the problem of guiding and controlling the flight of the product through the plant—flight at about 36 inches above the floor. Most important is the handling of the materials and parts from which the product is made.

Fourth, you cannot plan a layout with machine tools alone, because they represent only one-fifth or less of the pieces of equipment in the average plant. In the course of studying some 450 plants of all types, we found the average ratio of production machines to nonproductive equipment to be about 6-to-1. In a plant having a complement of some 6000 pieces of equipment, very rarely will the machines of a production nature consist of more than 800 plus or minus.

All the foregoing has been sketchily outlined in order to indicate the great number of technical facts that must be taken into consideration in any industrial planning project. The optimum plant layout technique will intelligently record, in the final layout, the group engineering and thinking which obviously will end in the spending of some millions of dollars.

From a paper entitled "Visualizing Plant Layout in Three Dimensions" presented at the Annual Meeting of ASTE in Philadelphia, April 1954.

MAGNETIC AMPLIFIERS IN INDUSTRY

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MAGNETIC AMPLIFIER story for machine tools is the story of regulating systems for machine tools. Regulators need not be peculiar to one specific industry; they are peculiar to a specific function that can be adapted to many industries. By observing functions performed in other industries by magnetic amplifiers, further use of these devices for machine tools will become apparent.

Pressing need for a rugged device plus recent developments in the core materials and rectifiers used in magnetic amplifiers, have focused much attention on their problems. World War II and the succeeding years have brought magnetic amplifiers a long way. Better core materials with so-called "square loop" characteristics have been developed. Good dry-type rectifiers are commercially available. The key which really unlocked the application door was the development of the self-saturating circuit, which uses rectifiers to increase amplifier gain tremendously. While the principles of operation of magnetic amplifiers have been known for many year, it was only recently that they have come into widespread use.

Functionally, this device is a variable reactance placed between the load and its power supply. By means of a small control signal, the reactance can be varied by as much as 100 to 1 with commercially available materials. Likewise, the voltage across the load

is varied by the same amount.

Amplifier Operation

To understand simply what goes on inside a magnetic amplifier, recall that the voltage across any reactance is proportional to the rate-of-change of magnetic flux in the iron. Now if the iron saturates, the flux can no longer change and the reactor voltage collapses. The core is said to have "fired." By use of the dc control windings, the degree of saturation is preset, and thus, so is the point at which the core will reach saturation, or "fire." If the flux is preset to a lower value, it takes longer to get back up to saturation. Thus the core "fires" later and the output is reduced.

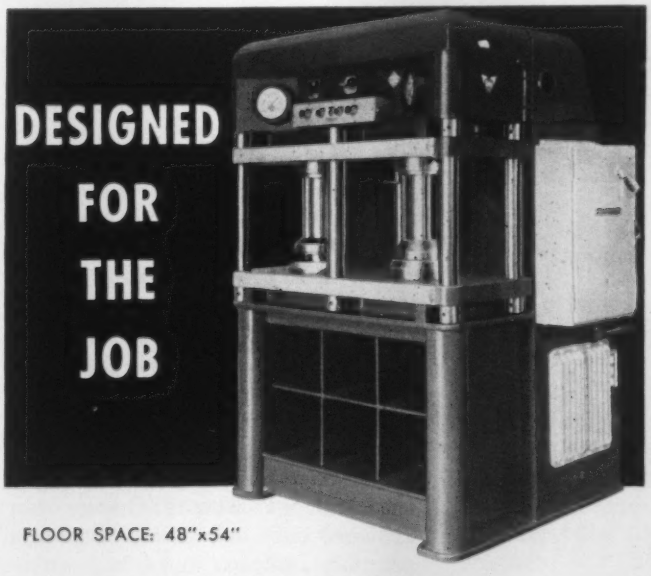
Like electronic amplifiers, magnetic amplifiers have the basic limitation of non-reversible output. When an application requires a reversible output, two amplifiers may be arranged in "push-pull." In this manner, one unit provides the positive output while the other unit provides the negative output. The "push-pull" scheme results in a theoretical maximum efficiency of only 17 per cent, and is therefore normally restricted to low power requirements. Preamplifiers for reversing applications are often "push-pull' units.

A more efficient but more costly method is to use two independent amplifiers working into separate fields on an exciter or generator. By thus controlling field excitation, the output voltage of the exciter may be varied smoothly from maximum positive voltage, smoothly through zero, to maximum negative voltage. It is well known, of course, that a rotating amplifier includes this feature inherently. While reversing applications may require two amplifiers, there are many applications which do not. Some examples of systems which use single-polarity control are voltage regulators, speed regulators, special computer circuits, and limiting circuits.

Limiting circuits, for example, are very important in regulator systems, especially when forcing action is required to effect fast response. If field forcing is used on the field of a dc machine to obtain rapid response, the action may be so rapid that dangerous currents will circulate. To prevent this, a current-limit magnetic amplifier can be used to throttle the forcing when the armature current reaches the maximum safe value. If a magnetic amplifier is already being used, say as a speed regulator, one additional winding on the amplifier may be utilized for current limit override. By utilizing suitable control signals, other quantities such as torque, speed, and voltage can be limited in a similar manner.

Applications

To consider some specific applications, we refer first to a two-stand temper-pass mill for tempering steel strip after annealing. The drive requirements are that the



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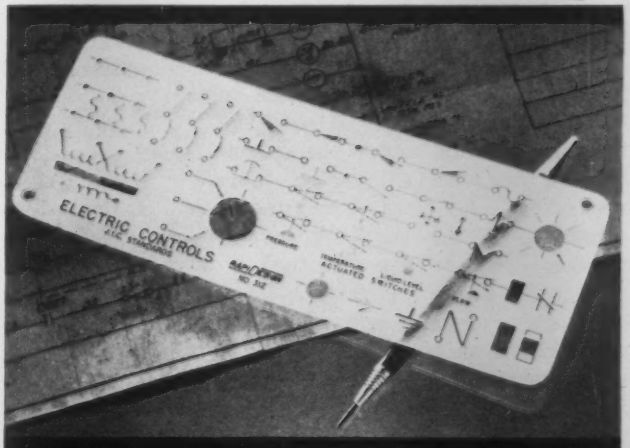

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tension in the strip be controlled closely. To accomplish this, strip tension is measured by a tensiometer. Since the strip bears directly against the tensiometer roll, any change in tension causes movement of the roll. This roll movement is converted to an electrical signal and fed to the control winding on the magnetic amplifier. The control signal is compared against the tension reference signal to control the output of the magnetic amplifier. The amplifier works into the field of a booster which changes the drive motor speed in such a direction to return strip tension to its original set value.

Another application of magnetic amplifiers has made possible the operation of a modern paper winder at the unprecedented speed of 5000 fpm. This winder receives 17-ton rolls of paper as they come from the paper machine, and operates to produce many smaller rolls more suitable for shipping and handling. Referring to the schematic representation of *Fig.* 1, the surface winder is seen to pull the paper from the core-type unwind stand. Braking on the unwind stand is carefully controlled by a braking generator to maintain constant tension in the paper.

For a fixed linear paper speed, the unwind roll speed increases as its diameter shrinks. To keep the tension constant under these conditions, one can show that it is necessary to hold armature current constant. Notice that the unwind tension regulator measures the current to the braking generator, compares it to a reference as set on the tension rheostat, and controls the generator excitation accordingly.

The booster is used to compensate for IR-drop and to provide tension current when the winder is at standstill. Three auxiliary magnetic amplifiers provide a slow, regulated speed for threading operations, and a current-limiting action during acceleration to full winder speed. Thus, the machine is accelerated and decelerated as rapidly as possible without circulating dangerous currents.

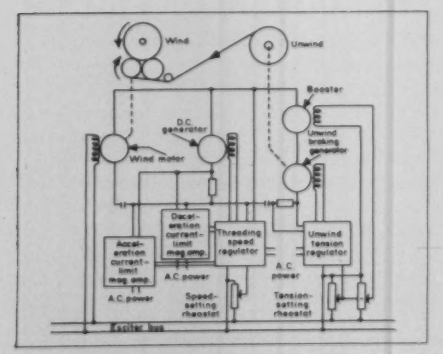

Fig. 1—Schematic for magamp controlled paper winder

Advantages and Disadvantages

It is well to know both the limitations and strong points of the magnetic amplifier to evaluate its application to a specific job.

Limitations of the magnetic amplifier may be listed as follows:

1. Single-polarity output.
2. Finite minimum time delay, dependent upon supply frequency.
3. Finite minimum signal level required.
4. Incomplete cutoff sets minimum output.
5. Somewhat temperature sensitive (over wide ranges).
6. Somewhat sensitive to variations in supply voltage and frequency.

On the other hand, the strong points of magnetic amplifiers include these advantages:

1. Static device with long life and minimum maintenance.
2. Shock resistance.
3. No warm-up period required.
4. Control windings isolated from each other and from the load windings.
5. Flexibility.
6. Fast response.
7. Device acts as variable reactor, not resistor. Therefore more efficient.

As more people become familiar with magnetic amplifier applications and gain more experience with them, the field will continue to grow larger. With the inherent reliability, simplicity, and ruggedness of the magnetic amplifier, control and design engineers are certain to utilize ever expanding field or regulated systems and automatic controls.

From a paper entitled, "Industrial Applications of Magnetic Amplifiers" presented at the Westinghouse Annual Machine Tool Electrification Forum in Buffalo, April, 1954.

PRACTICAL USES FOR NUCLEONICS

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NUCLEAR TECHNOLOGY today is invading many fields of industry. To know some of the ways in which this is happening may enable tool engineers to adopt this modern technology in their work. They will probably be most interested in applications, a few of which are elaborated here.

Radioactive tools and dies make it possible to detect very minute amounts of wear with ease and to localize the points of wear in great detail. The amount and location of transferred material can be studied quite easily. Photographic film can be placed in contact with the nonradioactive wearing surface. Development of the film then shows the locations where material has been transferred. This method has been used to study the wear of wire drawing dies and bearings.

The autoradiographic technique has proved exceedingly useful in the biological sciences to locate radioactive materials present in tissues. It should prove equally useful in metallurgy to locate minor components in metals, although it does not seem to have found as extensive use yet. In principle, a photographic film is placed in contact with the material of interest and left long enough so that the radiation emitted is sufficient to produce a latent image. It is then developed; modern autoradiographic film is made so that this can be done without removing the film from the material of interest so there are no problems of orientation.

Classical methods of studying corrosion by weight change can measure only net effects, although solution analyses make it possible to separate material loss and film formation. By the use of radioactive materials it is possible to measure the concentration of corrosion products easily and continuously if desired. It is also possible to determine the rate of corrosion of each component rather than just the gross corrosion rate.

Noncontacting gages are now commercially available for measuring the thickness of continuous

sheets of material without stopping the flow. Two types of gages are in general use: the transmission gage and the backscatter gage. The transmission gage has source and detector on opposite sides of the material in question. Any variation in the mass thickness of the material changes the transmission of radiation and results in a change in the reading of the detector.

This can be used to control the process. The backscatter gage has source and detector mounted on the same side of the material but shielded from each other. The amount of radiation scattered from the material into the detector is dependent on the thickness of the material and its composition. It is possible to make this gage so that it responds to the thickness of a coating and not to the backing material if there is some difference in atomic number.

Use of radioactive materials for static dissipation can eliminate any of the hazards, such as fires, which might be caused by static. Both alpha and soft beta emitters can be used. If source and material can be placed within an inch or two of each other, the dense ionization of the alpha particle makes it very desirable for this sort of function. If not, the longer range of the beta must be used and greater activity is necessary to compensate for the lower ionization.

Use of radioactive materials for the detection of flaws in castings or welds is an oldtime application.

In general, the applications are limited only by the knowledge and ingenuity of the user. In spite of the excellent training programs of the Atomic Energy Commission, and the great deal that has been written, many people are still only vaguely conscious of the help which nuclear technology can bring both to research and production. Through the sharing of problems by the tool engineers with nuclear specialists, we can both come to a better understanding of the ways in which these new nucleonic tools may be of specific use.

From a paper entitled, "Nucleonics Invades the Tool Engineering Field" presented at the Annual Meeting of ASTE in Philadelphia, April 1954.

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PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Communications

TELEPHONE ANSWERING AND RECORDING DEVICE AND MEANS FOR CONTROLLING

Transmitter, receiver and phonograph with translating means conditions transmitter to be used as recording microphone for phonograph. Patents 2,673,241 and 2,673,242 by Harry R. Van Deventer and Paul C. Bailey, assigned to Telephone Answering and Recording Corp.

Components

MAGNETIC INSERT FOR SEALING HEADS

For miniature lamp butt sealing machine. Patent 2,672,711 by Joseph C. Nash, assigned to Westinghouse Electric Corp.

DUMMY FEED FOR STEM MACHINES

Metal inserts entrained in air stream directed into mold cavity recess. Patent 2,672,712 by William Leroy Reiter, assigned to Sylvania Electric Products, Inc.

TABLE INDEXING MECHANISM

Two motors, one couples and uncouples the reciprocating motion of the other to cause intermittent rotary motion of the table. Patent 2,672,773 by H. Bruce Schofield.

REMOVABLE PUMPING TANK FOR AUTOMATIC DEVELOPING MACHINES

Cam engages operating member of pump only when tank is in operating position. Patent 2,673,-007 by Andre Victor Leon Clement Debrie.

Computers

ELECTRONIC MULTIPLIER

Product of two numbers each represented in binary scale of notation by a signal comprising a series of sequentially occurring electrical pulses. Patent 2,672,283 by Byron L. Havens, assigned to International Business Machines Corp.

TOTALIZING KEY PUNCH

An entry receiving device having a plurality of contacts set singly or in combination to represent the digits 1 to 9. Patent 2,672,286 by Hans P. Luhn, assigned to International Business Machines Corp.

Controls

INTEGRATING METER

With a shaft having angular movements in response to changes in value of a variable metered device adapted to actuate an electrical switch. Patent 2,672,285 by Russel D. Irwin, assigned to Minneapolis-Honeywell Regulator Co.

LIMIT SWITCH OPERATING MECHANISM

Flat spring slightly bowed when rotary element has not been rotated through its limited angular rotation; when actuated the spring is bowed still more and thus actuates the switch plunger. Patent 2,673,468 by Ralph P. Immel and Lawrence Pierce and Stanley Kmonk, Jr., assigned to Westinghouse Electric Corp.

FAULT INDICATING APPARATUS

For indicating any failure of a moveable member to reach a prescribed position in response to a control operation. Patent 2,672,601 by Brian Guy Welby, assigned to Ferranti Ltd.

AUTOMATIC PILOT MECHANISM FOR SELF PROPELLED VEHICLES

Gyroscope actuates pair of servoswitches in response to deviations of the vehicle from a preselected heading to cause automatic steering control apparatus to turn vehicle to left or right. Patent 2,674,332 by Stanford R. Ovshinsky.

Data Processing

SENSING OF PERFORATED STATISTICAL RECORDS

Apparatus using photoelectric cells to actuate timing devices to feed punched cards through sensing chambers. Patent 2,672,288 by John Perrin assigned to Powers-Samas Accounting Machine Ltd.

DATA STORAGE, READ OUT, AND COMPARISON DEVICE

Groups of wires on circumferential plane each representing a value, electromagnetically displaced from the plane by separate data sources in opposite groups, electromagnetically compared and restored to position. Patent 2,673,032 by Hans P. Luhn, assigned to International Business Machines Corp.

PRINTING MACHINE

Prints digits upon a sheet corresponding to digits represented by holes in the control cards. Accumulates digital values printed on sheet and then prints the accumulated values. Patent 2,673,033 by John H. Grover, assigned to Addressograph-Multigraph Corp.

Handling

HOPPER DISCHARGE FOR ELONGATED RODS

Rods placed indiscriminately in an inclined sidewall hopper which reciprocates in a direction lengthwise to its elongated discharge opening are oriented and fed to assembly machine or the like. Patent 2,674,755 by Theodore F. Schlicksupp.

APPARATUS FOR AUTOMATICALLY CENTERING MOVING OBJECTS

Flexible webs fastened such that two rims rotate at same angular velocity and tilt toward each other progressively at the points of contact with the moving object on the approach side. Patent 2,674,455 by Alfred Teplitz, assigned to United States Steel Corp.

BELT GUIDE AND TAKE UP

Deviations of the lower run of the conveyor belt from its normal course displace a pair of rollers engaged by opposite belt edges and impart pivotal movement to the yoke holding the tail pulley, swinging it to guide the belt automatically back to normal position. Patent 2,674,366, by Harold V. Kindseth and Frank L. Hopkins, assigned to Bemis Bros. Bag Co.

CHAIN TYPE MINE CONVEYOR

Endless chain for moving material over a plane surface—every other link closed intermediate links adapted to receive sprocket teeth. Patent 2,672,971 by Joseph T. Joy, assigned to Joy Mfg. Co.

Machines

SHANK SLOTTING MACHINES

Milling machine for cross-slotting the shanks of rivets fed from delivery station to indexing disk and transferred to each of two sawing stations where hold down means are actuated and saws are fed up into the workpieces which are then indexed to the ejecting station. Patent 2,674,754 by W. C. Hale, Jr., assigned to South Chester Corp.

AUTOMATIC EGG CLEANING MACHINE

Conveyor to positively move rolling eggs under rotating light abrasive elements centrifugally flung outwardly into the path of the eggs. Reissue patent 23,809 by Clyde C. Powell, assigned to National Poultry Equipment Co.

MOLDING APPARATUS

Multistation turntable with molding presses mounted on table—equipped with nozzle for extruding plastic material into cavities of presses. Patent 2,672,652 by Everett W. Howe, Harry E. Cooper, and Otto F. Homeier, assigned to U. S. Rubber Co.

APPARATUS FOR ASSEMBLING COMMUTATORS

Ejector and pair of rotatable heads move mica strips from positioning shelf onto top of supported copper bar and assemble selected number into commutator. Patent 2,674,033 by Robert Henry Bojewicz and Charles Raymond Fish, assigned to Reconstruction Finance Corp.

Measuring

FLATNESS INDICATOR FOR CELLOPHANE FILM

Feeler elements spaced transversely, biased for tensioning selected lanes of an unsupported span of film connect with variable electrical input means and network for measuring and correlating the variations. Patent 2,674,127 by John E. Garrett, Michael B. Karelitz and Delbert R. Jones, assigned to Olin Industries.

Merchandising

COIN OR TOKEN OPERATED DEVICE

Tracks for various sizes of coins and reject mechanism to prevent entry into any of the tracks. Patent 2,672,967 by Ernest E. York, assigned to American Coin Changer Corp.

COIN COLLECTING DEVICE WITH SHORT AND LONG TIME OPERATION

For an electric timer with a start and stop position, turntable moves coin from input slot to

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BY IRVING J. HOGAN

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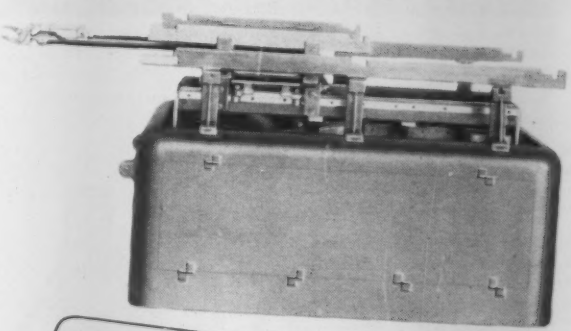

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discharge opening. Patent 2,672,968 by Harry Greenwald, assigned to Robco Corp.

COIN CONTROLLED TIMER

Coin collecting device for an electric timer with coin in slot cam and pin driven from start to stop position. Patent 2,672,969 by Harry Greenwald, assigned to Robco Corp.

Packaging

DISPENSING AND MEASURING APPARATUS

Adapted to handling hygroscopic granular materials in heated chamber and actuated by the container being filled. Patents 2,672,006 and 2,673,017 by William J. Emmons and Bernard S. Gellagher, assigned to Salter Machine Co.

APPARATUS FOR FORMING AND WRAPPING PRODUCTS

Feeds bar material and strip wrapper, knife forces wrapper through the bar cutting off the material, then knife moves to sever the wrapper. Patent 2,673,429 by Edward J. Riebe.

WRAPPING MACHINE

Paper wrapper and stack of biscuits fed from conveyor by elevator to wrapping wheel. Patent 2,672,717 by Alexander Russell, Alan Hopton and Arthur Francis Carter, assigned to the Fargrove Machinery Co. Ltd.

RECEPTABLE FILLING MACHINE

Annular body with internal cavity opening, ported by annular valving member successively inresistry with the movement of containers along predetermined path. Patent 2,673,019 by Dennis W. Smith, assigned to Colborne Mfg. Co.

FILLING MACHINE

Electrically operated means to control flow of fluid pressure alternately into opposite ends of measuring cylinder and filling nozzles. Patent 2,673,012 by Bertie S. Harrington, assigned to Armour & Co.

PACKAGING APPARATUS

Wraps annular rayon cakes with tubular covering material from roll stock. Patent 2,673,432 by John O'Haw, assigned to E. I. du Pont de Nemours & Co.

Systems

CLOCK SETTING MECHANISM AND CIRCUIT

Master clock and pilot clock having impulse motor with plurality of secondary clocks each having impulse motor energized by circuit consisting of control relay, intermittent circuit breaker, and switch. Patent 2,672,008 by Henry Maerz assigned to Self Winding Clock Co. Inc.

Warehousing

ARTICLE DISPENSING SYSTEM

Storage and release of items from coded devices at various distances from a common delivery point and connected therewith by conveying means. Patent 2,672,219 covers control arrangement and patent 2,672,289 the system by Thomas S. Skillman, assigned to Punch Engineering Pty. Ltd.

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ENGINEERING ANALYSIS

By D. W. Ver Planck, head, Department of Mechanical Engineering, Carnegie Institute of Technology; and B. R. Teare, Jr., dean, College of Engineering and Science, Carnegie Institute of Technology; 344 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons, Inc., New York; available from AUTOMATION, *$6.00 postpaid.*

The authors of this book have presented a basic exposition of the professional method as it applies to the analysis of engineering problems. Important elements of the professional method discussed are: defining the problem to be solved; deciding what principle to apply; choosing co-ordinate systems; checking thoroughly; choosing dimensionless variables; and the sketching of curves.

The book deals with topics needed by engineers both for use and understanding. These include material from dynamics of translation and rotation, electric circuits, heat transfer, solution of linear differential equations with constant coefficients, uses of power series, integration by graphical and numerical methods, hyperbolic functions, and the evaluation of indeterminate forms. An extensive collection of problems are included to enable the reader to apply the material gained from the book.

♦

LINEAR TRANSIENT ANALYSIS

By Ernst Weber, D.Sc., Ph.D., professor of electrical engineering, Polytechnic Institute of Brooklyn; 348 pages, 6 by 9 inches, clothbound; published by John Wiley & Sons, Inc., New York; available from AUTOMATION, *$7.50 postpaid.*

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Integro-differential equations are used to review the formulations of transients in linear networks. The author discusses Heaviside's operational method with the modifications given it by H. Jeffreys. He also includes an examination of the Laplace transform concept and the Fourier integral methods.

The needed mathematical background for various sections is reviewed in appendices, which also include notes on the symbols using a short bibliography of relevant books.

Government Publications

Multiple-Loop Control in Turbojets. *34 pages; available from National Advisory Committee for Aeronautics, 1512 H St. N.W., Washington 25, D. C.*

An analog study of interacting and noninteracting multiple-loop control systems for turbojet engines determines optimum form for compensation terms for engine interaction and shows that complete compensation eliminates engine interaction and permits each loop to be developed to optimum point independently.

♦

Graphical Analysis of Some Transistor Switching Circuits. *Report PB 112636 by International Business Machines Corp.; 11 pages; available from Library of Commerce, Publication Board Project, Washington 25, D. C.; $1.75 per microfilm, $2.50 per photostat.*

How to generate entire input characteristic for the various terminals of a transistor and how to analyze graphically three direct-coupled transistor circuits are the subjects of this report. Circuits are a base input amplifier, a collector-to-emitter direct-coupled switching circuit, and a collector-to-base direct-coupled circuit. Analysis utilizes va characteristics of both linear and nonlinear devices.

♦

Instrumentation. *Available from Office of Technical Services, (Order No. 111464), U. S. Dept. of Commerce, Washington 25, D. C.;* $2.00.

First in a series of seven volumes lists 775 government-owned inventions in the field of instrumentation. Listings are divided into eight subgroups: laboratory, scientific and engineering instruments; instruments for indicating, measuring, and recording electrical quantities and characteristics; mechanical measuring and controlling instruments; optical instruments and lenses; surgical and medical instruments; X-ray and therapeutic apparatus; surgical and orthopedic appliances and supplies; photographic equipment and supplies.

♦

Association Publication

Strategic Areas In Cost Reduction. AMA Manufacturing Series, Number 215; *28 pages; available from American Management Association, 330 West 42nd St., New York 18, N. Y.;* $1.25.

Papers by four authorities in the management field discuss different means of cost reduction. "Purchasing for Profit," by Stuart F. Heinritz, outlines the potentialities of the purchasing agent in this field; R. A. Peterson's "Slicing Waste Effort from Materials Handling" describes cost reductions achieved through installation of automatic equipment and handling in a new warehouse. The other two articles are: "Increased Efficiency Through Preventive Maintenance" by George J. Martin, and "Top Management Views Cost-Cutting Controls," by Warren C. MacFarlane.

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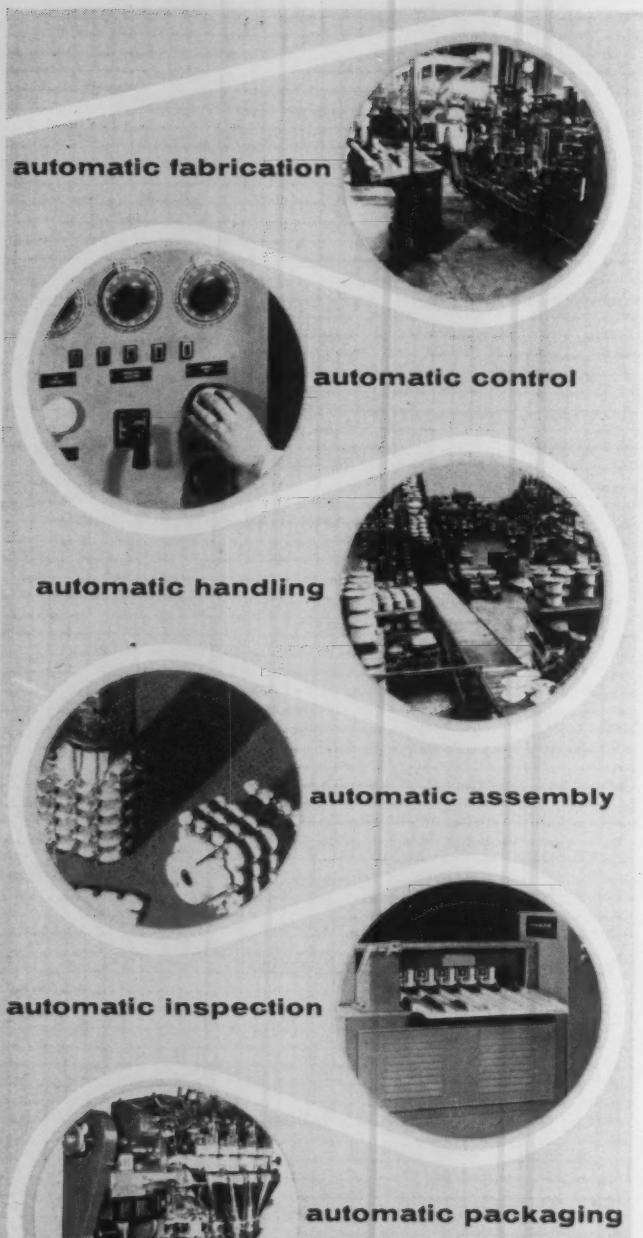

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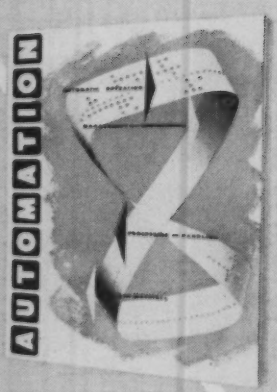

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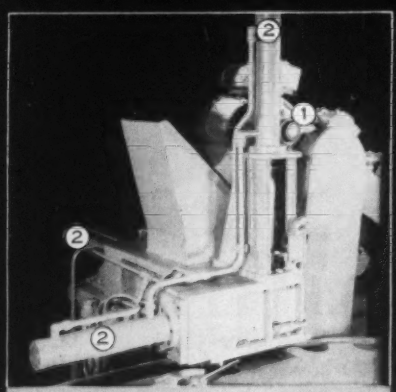
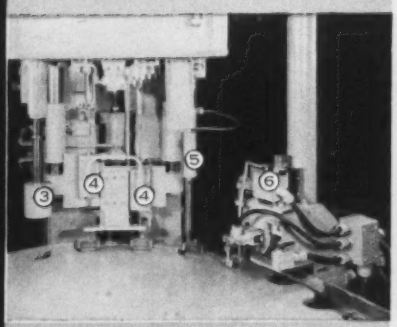
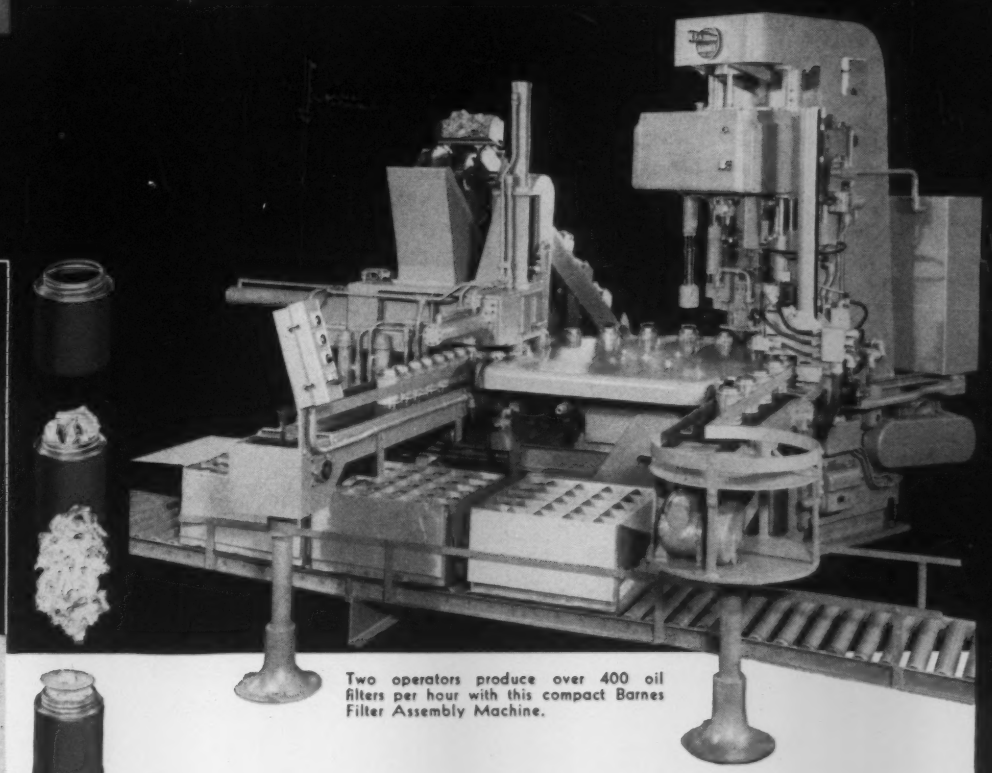
increased production 220% through AUTOMATIC ASSEMBLY of oil filters



Operator stationed at front of machine feeds empty cans from cartons at the left-hand side. Cans are automatically conveyed to star wheel. Second operator at rear of machine measures cotton waste, which conveyor (1) carries to hopper of compressing and loading cylinders (2). Same operator places wire screen and retainer on filter as it indexes to the next station.



Automatic plunger (3) forces screen and retainer into filter body. Two oscillating air drills (4) weave oil hole through cotton waste. Automatic gauge (5) checks depth of hole, ejecting defective units from machine. Next unit (6) automatically adds cork gasket to complete the assembly. Cartons are moved along conveyor to the discharge side of the machine, where they are repacked with completed filters.



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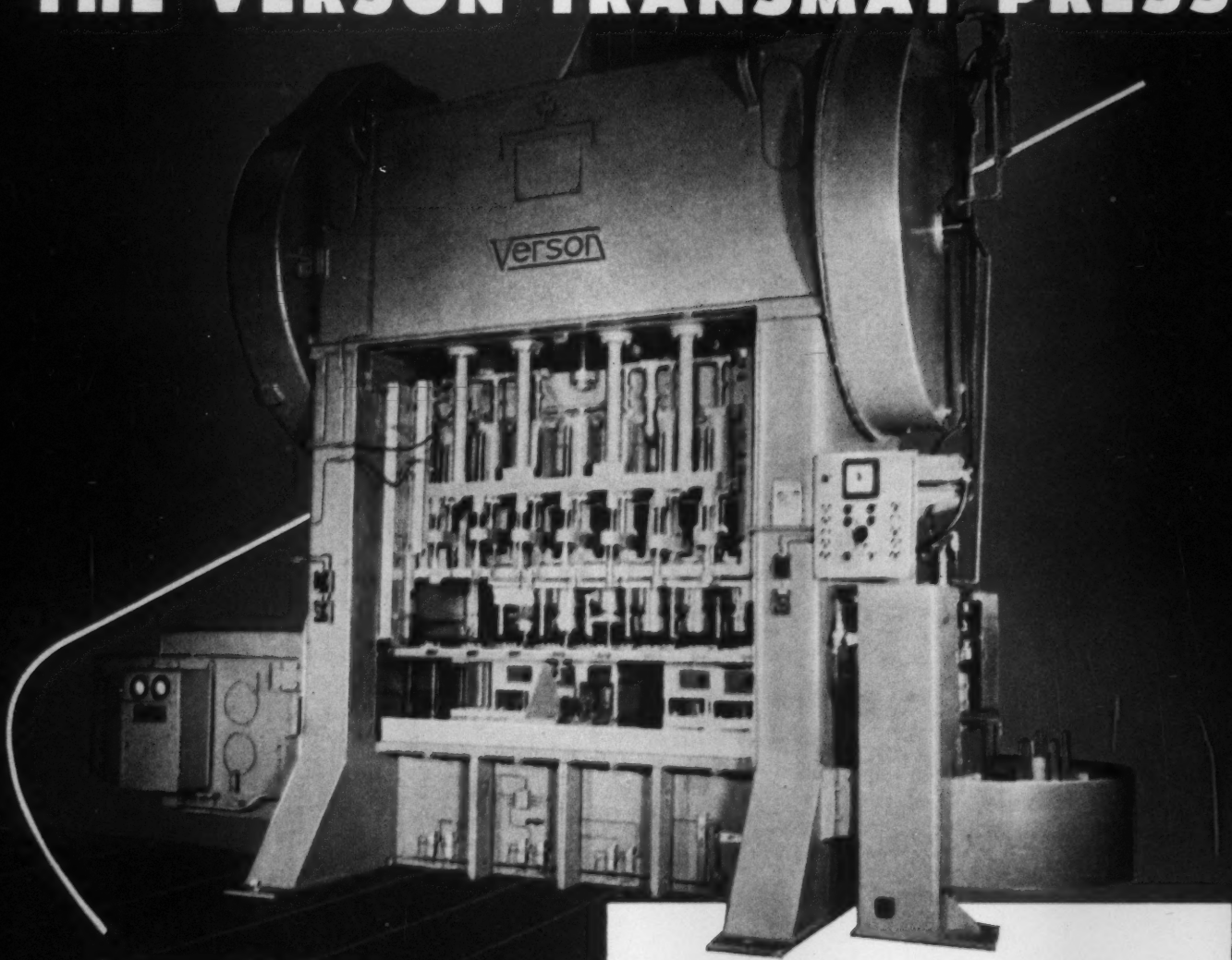

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